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Special Issue — Review of Biology and Fisheries for Smaller Cetaceans

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Environnement Canada
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Review of Biology and Fisheries for Smaller Cetaceans

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Le droit de publication de ce numéro spécial du Journal de l'Office des recherches sur les pêcheries du Canada est réservé coinjointement à la Commission internationale de la chasse à la baleine et à Information Canada.

Foreword

The International Whaling Commission has been primarily concerned with the statistics, science, protection, and optimum utilization of the large cetaceans. Knowledge of these "Great Whales" is becoming good enough to provide for their effective management. As catches of large whales have decreased, catches of small whales, porpoises, and dolphins have increased, and attention has been shifting to problems associated with their conservation and rational utilization.

The catch statistics for both large and small cetaceans have been published annually for the International Whaling Commission, with increasing sophistication.

By 1974, international interest in the smaller cetaceans increased sharply. D. Truitt published a comprehensive annotated bibliography of the smaller Cetacea. The International Union for Conservation of Nature and Natural Resources sponsored a study of the "Porpoise, Dolphin and Small Whale Fisheries of the World" and is publishing Dr Mitchell's monograph on the subject in 1975. The Food and Agriculture Organization's Working Party on Marine Mammals formed a group of experts on "Small Cetaceans and Sirenians" under the chairmanship of Dr Mitchell. It is dealing with the most obvious conservation problems and is preparing contributions to an international conference on marine mammals planned for 1976.

In April, 1974, the International Whaling Commission's Scientific Subcommittee on Smaller Cetaceans held a special meeting to review the biology, geographical subdivisions and fisheries status of each species of smaller cetaceans. The meeting was held in Montreal, Canada, under the chairmanship of Dr Mitchell. This issue of the Journal of the Fisheries Research Board documents the report and papers resulting from that meeting. It is the product of the initiative of the Whaling Commission and its Scientific Committee, the dedication of a small group of international scientific experts on the smaller cetaceans, and the financial support of a few member governments and friends of the International Whaling Commission.

These initiatives are providing an informed base for international discussions concerning the requirements for scientific study, management, and wise use of the world's cetaceans, an important component of the living resources of the seas. It is expected that the Law of the Sea Conference will lead to new conventions, including a new Cetacean Convention with a broader mandate than that of the International Whaling Convention. The need for better international statistics, much more science concerning the smaller cetaceans and their roles in aquatic ecosystems, and new institutional arrangements for effective management of these resources and their use by man, has become much clearer as a result of these international efforts to document the inadequate state of our existing knowledge of the smaller cetaceans.

Dr Mitchell and the small number of world experts who have worked with him have served us well.

W. R. MARTIN
Senior Scientific Advisor
Fisheries Research Board of Canada
and Canadian Whaling Commissioner.

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Avant-propos

La Commission internationale de la chasse à la baleine s'est occupée principalement de statistiques, science, protection et utilisation optimale des grands cétacés. Les connaissances acquises sur les « grandes baleines » sont maintenant suffisantes pour une gestion efficace. A mesure qui diminuaient les prises de grandes baleines, celles des petites baleines, des marsouins et des dauphins augmentèrent, et l'attention s'est déplacée vers les problèmes associés à la conservation et à l'utilisation rationnelle de ces derniers.

Les statistiques de capture, tant des grands que des petits cétacés, sont publiées annuellement, avec toujours plus de raffinement, par la Commission internationale de la chasse à la baleine.

1974 vit un accroissement brusque de l'intérêt de la communauté internationale dans les petits cétacés. D. Truitt publia une bibliographie annotée complète des petits Cetacea. L'Union internationale pour la conservation de la nature et des ressources naturelles commandita une étude, « Porpoise, Dolphin and Small Whale Fisheries of the World », et publiera en 1975 la monographie de M. Mitchell sur le sujet. Le Groupe de travail de l'Organisation pour l'alimentation et l'agriculture sur les mammifères marins forma un groupe d'experts sur les « petits cétacés et siréniens », dont M. Mitchell est le président. Ce groupe s'occupe des problèmes de conservation les plus évidents et est en train de préparer des contributions pour une conférence internationale sur les mammifères marins prévue pour 1970.

En avril 1974, le Sous-comité scientifique des petits cétacés de la Commission internationale de la chasse à la baleine tint une réunion spéciale où l'on fit la revue de la biologie, des subdivisions géographiques et du statut des pêcheries de chaque espèce de petits cétacés. La réunion eut lieu à Montréal, Canada, sous la présidence de M. Mitchell. Le présent numéro du Journal de l'Office des recherches sur les pêcheries contient le rapport et les articles découlant de cette réunion. On y voit le produit de l'initiative de la Commission internationale de la chasse à la baleine et de son Comité scientifique, du dévouement d'un petit groupe de scientifiques experts en petits cétacés, et de l'aide financière de quelques gouvernements membres et d'amis de la Commission internationale de la chasse à la baleine.

Grâce à ces initiatives, nous possédons des connaissances de base qui serviront lors de discussions internationales sur la nécessité d'études scientifiques, d'une gestion et d'une sage utilisation des cétacés du monde, une composante importante des ressources vivantes de la mer. Il est probable que la Conférence sur le droit de la mer aboutira à de nouvelles conventions, y compris une nouvelle Convention sur les cétacés, à mandat plus étendu que celui de la Convention internationale sur la chasse à la baleine. Ces efforts internationaux en vue de documenter l'état insuffisant de nos connaissances actuelles sur les petits cétacés firent ressortir le besoin de meilleures statistiques internationales, de beaucoup plus de recherche scientifique sur les petits cétacés et leur rôle dans les écosystèmes aquatiques, et de nouvelles structures institutionelles pour la gestion efficace de ces ressources et leur utilisation par l'homme.

M. Mitchell et le petit nombre d'experts mondiaux qui ont travaillé avec lui nous ont bien servi.

W. R. Martin
Conseiller scientifique supérieur Office des recherches sur les pêcheries du Canada et Commissaire canadien auprès de la Commission international de la chasse à la baleine

Frontispiece — Boat-steerer attempting to harpoon a common dolphin, *Delphinus delphis*, from the back ropes and jib-boom martingales on an American whale ship of the 1840s. Dolphins and porpoises were common prey of whalemen — the perpendicular spar below the bowsprit is called the "dolphin striker" — and were fully utilized. On catching one, Ashley (1942) remarks, "that night we had the first fresh meat in weeks, and for two days we feasted on porpoise steaks and liver. The steaks are a trifle oily, perhaps, but the liver is as good as any. Sea-pig he is called by the sailors. The cook tried-out the head and jaw oil, the cabin-boy saved the teeth, and Mr. Gomes cut the crotch from the flukes for a talisman and nailed it to the cutting-stage — the first catch of the season." Mr F. Armitage of Los Angeles researched and painted this frontispiece to illustrate the long history of porpoise fishing.

Frontispiece — Timonier tentant de harponner un dauphin commun, *Delphinus delphis*, des cables arrière et martingales du bâton de foc sur un baleinier américain des années 1840. Les dauphins et les marsouins étaient des proies communes pour les chasseurs de baleines — les Anglais appellent « dolphin striker » l'espar perpendiculaire sous le beaupré (arc-boutant de martingale) — et étaient pleinement utilisés. Après la capture d'un animal, Ashley (1942) écrit: « cette nuit-là, nous avons mangé de la viande fraîche pour la première fois depuis des semaines et, pendant deux jours, nous nous sommes régalés de biftecks et de foie de marsouin. Les tranches sont peut-être un tant soit peu huileuses, mais le foie est aussi bon que celui de tout autre animal. Les marins l'appellent porc de mer. Le cuisinier fit l'essai de l'huile de la tête et de la machoire, le mousse conserva les dents, et M. Gomes coupa la fourche de la nageoire de la queue comme talisman et la cloua sur la plateforme de tranchage — la première prise de la saison. » M. F. Armitage, de Los Angeles, fit les recherches et peignit ce frontispice illustrant la longue histoire de la pêche des marsouins.

Preface

There is much world interest in the conservation of porpoises, dolphins, and small whales. Many intergovernmental, conservational, and other organizations have recently expressed interest in discussing the problems, but all have encountered difficulties in assembling data and learning of previously published, relevant papers. Experts will be able to find their way, but the general reader, conservationist, or manager will want some guidance.

Basic data on the history of exploitation, modern catch levels through 1972–73, the pinpointing of specific problem areas, and extracts from relevant but often difficult to obtain published papers will be found in my paper "Porpoise, dolphin and small whale fisheries of the world," commissioned by the S.S.C. Whale Group, and published by I.U.C.N. (Monograph 3: 1–129, 1975). The contents of this Special Issue include species by species enumeration of biological parameters, review of fisheries by geographic regions and technology, and summary of interrelationships of these fisheries to other fin-fish fisheries along with 26 original papers. Specific references on some aspects of dolphin and porpoise biology, including fisheries and conservation, are classified in a bibliography of 3549 titles recently compiled by D. Truitt (Dolphins and porpoises: a comprehensive, annotated bibliography of small Cetacea, Gale Research Co., Book Tower, Detroit, xii, 582 p., 1974). The F.A.O.–A.C.M.R.R. Working Party on Marine Mammals sponsored a meeting of "Group II — Small Cetaceans and Sirenians" in La Jolla on December 16–19, 1974, that is expected to produce a report on the particularly troublesome conservation problems. This report and attendant working papers and recommendations will be discussed at an international conference in 1976, and subsequently published.

This special issue of the Journal of the Fisheries Research Board of Canada *is devoted to the proceedings and papers of the meeting of the Subcommittee on Small Cetaceans of the Scientific Committee, International Whaling Commission held in Montreal, April 1–11, 1974. Members of the standing subcommittee as well as invited experts, observers, and other official representatives sponsored by Governments attended the 9 days of sessions.*

The objectives were to review the relevant published literature, catch statistics, and other data in order to compile for each species of dolphin, porpoise, and small whale the relevant data on status and possible geographic subdivisions of species, the initial size of each stock, recent catches, and information on the present status of populations.

Two categories of papers were prepared; formal papers, covering specific areas of interest to the meeting, and working documents giving background information for use in drafting the final meeting Report.

Authors were asked to revise some papers after the meeting, in light of discussions in Montreal. However, it was impossible for some authors who were at sea away from their home offices. Thus, although some editing has been carried out, all of these papers should be regarded as the status of the author's work as of April 1, 1974.

The meeting broke into a series of working groups, each responsible for drafting the wording of the Report for their respective assignments. Each of these reports was then discussed, and the wording of the entire report was agreed to, in full session. In some sections (e.g. Regional Accounts of Fisheries, Types of Fisheries for Cetaceans, and elsewhere), the working draft of the manuscript prepared for the I.U.C.N. was used as the point of departure for the text of the IWC Report. In other sections (especially the systematic review of species and stocks), unpublished material and special knowledge of attendees were relied upon heavily.

The original Agenda included as Item 8.1, a "Summary and recommendations to the Scientific Committee." However, in view of the breadth of the data, number of species, and diversity of problems covered, and because of the short time remaining in the meeting, all agreed that we delete "recommendations" and that the Chairman be asked to write an Executive Summary for Item 8.1. This was subsequently circulated at the Scientific Committee meeting of IWC in June 1974, as an unnumbered document.

The Scientific Committee recommended publication of the Report and Invited Papers, to the Plenary Session of the IWC. Support for publication came mainly from the Governments of Canada, the United States, and Norway. Additional support was offered by the Australian Government.

I have edited the Report lightly, wishing to preserve the agreed-upon wording as much as possible. Many additional literature citations were added after the meeting. Individual papers were edited by me and a minimum of one outside reviewer, subsequent to discussions at the meeting. Invited Papers have been arranged, in order and under the headings used in the Report. A number of scientists and others (acknowledged in the captions) kindly contributed photographs used to illustrate the Report. Mr F. Armitage accepted a commission on short notice to illustrate the long history of porpoise fishing.

I wish to thank Dr W. R. Martin for his continued encouragement and substantial aid in holding the meeting in Montreal, and in following it up through formal publication of the results. Dr W. F. Perrin has been a constant source of help and information on this and on the I.U.C.N. report on small cetacean fisheries. All who attended the meeting, and many others not able to attend, contributed materially to its success.

EDWARD MITCHELL
Convenor and Chairman
Subcommittee on Small Cetaceans
Scientific Committee
International Whaling Commission

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Préface

La conservation des marsouins, des dauphins et des petites baleines suscite un intérêt dans le monde entier. Plusieurs agences intergouvernementales, organismes de conservation et autres se sont récemment montrés intéressés à discuter des problèmes qui se rattachent à ces espèces, mais ils ont tous eu peine à rassembler des données et à trouver des publications pertinentes. Les experts pourront sans doute s'y retrouver, mais le public en général, le conservationiste et le responsable de la gestion auront besoin de conseils.

On trouvera dans mon article « Porpoise, dolphin and small whale fisheries of the world », commandité par le Groupe des baleines du SSC et publié par l'Union internationale pour la conservation de la nature (Monographie 3: 1–129, 1975), les données de fond sur l'historique de l'exploitation, les niveaux récents de capture jusqu'à 1972–73 inclusivement, l'identification de problèmes spécifiques et des extraits de publications pertinentes mais difficiles d'accès. Ce numéro spécial contient une énumération par espèces des paramètres biologiques, une revue des pêches par régions et par technologies et un résumé des relations qu'ont ces pêcheries avec d'autres pêcheries, et enfin plus de 26 articles originaux. On trouvera des références spécifiques sur quelques aspects de la biologie des dauphins et des marsouins, y compris pêche et conservation, dans l'excellente bibliographie (3549 titres) récemment préparée par D. Truitt (Dolphins and porpoises: a comprehensive, annotated bibliography of small Cetacea, Gale Research Co., Book Tower, Detroit. xii, 582 p., 1974). Le Groupe de travail FAO–ACMRR sur les mammifères marins organisa une réunion du « Groupe II — Petits cétacés et siréniens » à La Jolla, du 16 au 19 décembre 1974. On s'attend qu'il en résultera un rapport sur les problèmes, particulièrement épineux, de conservation. Ce rapport, de même que les documents de travail et les recommandations qui l'accompagneront, sera discuté lors d'une conférence internationale en 1976 et publié par la suite.

Ce numéro spécial du Journal de l'Office des recherches sur les pêcheries du Canada *renferme les comptes rendus et les articles de la réunion du Sous-comité des petits cétacés du Comité scientifique, Commission international de la chasse à la baleine, tenue à Montréal du 1er au 11 avril 1974. Les membres du Sous-comité permanent, ainsi que des experts, des observateurs et autres représentants officiels de gouvernements, participèrent à ces assises de 9 jours.*

Cette réunion avait comme objectifs de passer en revue la littérature pertinente, les statistiques de capture et autres données qui permettront de compiler, pour chaque espèce de dauphins, marsouins et petites baleines, les renseignements sur le statut et les subdivisions géographiques possibles des espèces, la grandeur initiale de chaque stock, les prises récentes et le statut actuel des populations.

On a préparé deux catégories d'articles: des articles en due forme portant sur des points d'intérêt particulier pour la réunion, et des documents de travail contenant les renseignements de base qui serviront à la rédaction du Rapport final de la réunion.

On a demandé aux auteurs de réviser certains articles après la réunion, à la lumière des discussions qui ont eu lieu à Montréal. Cependant, quelques auteurs n'ont pu le faire, étant en mer et éloignés de leurs bureaux. Bien qu'il y ait eu du travail d'édition de fait, tous ces articles doivent donc être considérés comme représentant le travail de l'auteur au 1er avril 1974.

La réunion s'est divisée en plusieurs groupes de travail, ayant chacun la responsabilité de préparer un premier jet du Rapport dans le domaine qu'on lui avait désigné. Chaque rapport fut ensuite discuté et on se mit d'accord, en réunion plénière, sur la rédaction du Rapport entier. Dans certaines sections (e.g. descriptions régionales des pêches, types de pêche des cétacés, et autres), le projet de manuscrit préparé à l'intention de l'UICN servit de point de départ au texte du Rapport de la CICB. Dans d'autres sections (surtout celle portant sur la revue systématique des espèces et des stocks), on s'est fortement appuyé sur du matériel inédit et sur les connaissances spéciales des participants.

L'ordre du jour initial comprenait, comme item 8.1, un « Résumé et recommandations au Comité scientifique ». Cependant, devant l'envergure des données, le nombre d'espèces et la diversité des problèmes couverts, et aussi à cause du manque de temps à la fin de la réunion, il a été unanimement décidé de supprimer les « recommandations » et de charger le président de préparer un résumé administratif couvrant l'item 8.1. Ce résumé fut par la suite distribué à la réunion du Comité scientifique de la CICB en juin 1974 comme document non numéroté.

Le Comité scientifique recommanda à la réunion plénière de la CICB que le Rapport et les articles produits sur invitation soient publiés. Le travail de publication fut patronné en grande partie par les gouvernements du Canada, des Etats-Unis et de la Norvège. Le gouvernement australien ont également offert leur assistance.

Je n'a édité que légèrement le Rapport, désirant lui conserver autant que possible la forme sur laquelle on s'était mis d'accord. Quelques citations extraites de la littérature ont été ajoutées après la réunion. J'ai moi-même, aidé d'au moins un critique de l'extérieur, édité les articles individuels. Les articles préparés sur invitation ont été arrangés dans l'ordre et selon les en-têtes du Rapport. Plusieurs scientifiques et autres (mentionnés dans les légendes) nous ont aimablement fourni des photographies pour illustrer le Rapport. M. F. Armitage a bien voulu, à brève échéance, se charger d'illustrer la longue histoire de la pêche des marsouins.

Je désire remercier M. W. R. Martin pour son encouragement continu et son aide substantielle lors de la réunion de Montréal et, par la suite, dans la publication des résultats. M. W. F. Perrin fut une source constante d'aide et de renseignements tant pour ce Rapport que pour le Rapport de l'UICN sur les pêches des petits cétacés. Toutes les personnes présentes à la réunion et plusieurs autres, incapables d'y assister, contribuèrent matériellement à son succès.

EDWARD MITCHELL
Convocateur et président
Sous-comité des petits cétacés
Comité scientifique
Commission internationale de la chasse à la baleine

Imprimé au Canada (J3644)

Review of Biology and Fisheries for Smaller Cetaceans

Report and Papers from a meeting of the Subcommittee on Smaller Cetaceans, International Whaling Commission, in Montreal, April 1–11, 1974

EDWARD MITCHELL

SPECIAL EDITOR

Report of the Meeting on Smaller Cetaceans
Montreal, April 1–11, 1974

1. Research and Information

1.1. Introductory Remarks

The 25th Annual Meeting of the International Whaling Commission held in June 1973 endorsed the recommendation of its Scientific Committee that a meeting of a Subcommittee on Small Cetaceans be held.

1.2. Terms of Reference

The meeting was held "to review relevant published literature, catch statistics and other data in order to compile a list for each species of smaller cetaceans of the following data:

1) species and possible geographic subdivisions
2) initial population size
3) recent catches
4) present population status

Other experts would be invited to participate as convenient."

The meeting was held at the Arctic Biological Station, Ste. Anne de Bellevue, Quebec.

Members (M) of the Subcommittee, invited experts (E), observers (O), and official representatives sponsored by governments (R) present were:

Canada:	E. Mitchell (Chmn, R)
	D. E. Sergeant (E)
	V. M. Kozicki (E)
	J. S. Beckett (E)
	M. A. Bigg (E)
	P. Brodie (E)
	M. C. Mercer (E)
	J. Geraci (E)
	A. Alpers (O)
	R. Olsen (O)
	B. Peers (O)
	H. Malcolm (O)
Chile:	A. Aguayo L. (E)
France:	Ch. Roux (M, R)
Japan:	S. Ohsumi (M, R)
	T. Ichihara (E, R)
	M. Nishiwaki (E, O, FAO)
Mexico:	D. Lluch B. (M, R)
Netherlands:	P. J. H. van Bree (E, R)
Norway:	I. Christensen (M, R)
USA:	W. F. Perrin (M, R)
	J. G. Mead (E)
	E. D. Asper (E)
	R. L. Brownell Jr. (E)
	D. K. Odell (E)
	K. Darling (O)
	S. Rathbun (O)

1.3. Adoption of Agenda

The draft agenda was adopted with modifications, the final version being appended as Appendix A.

2. Review of Smaller Cetacea, Identity and Status of Species and Stocks

GENERAL COMMENTS

2.1. Systematics of Species

The meeting decided upon a revised listing of species for discussion (Appendix B). Comments on the taxonomy of genera and groups of species, used in arriving at the list, are set out as footnotes in Appendix B. Comments on the taxonomy of individual species may also appear below, under item 2.1 in each species account. An agreed upon list of recommended common names, for use in English, is also given in Appendix B.

2.2. Number and Distribution of Stocks

Although many nominal species of small cetaceans have been determined to be conspecific in recent years (thereby reducing the number of recognized species), all well-defined species that have been critically examined have been found to contain two or more distinct geographical forms or stocks. Pronounced geographical differentiation appears to be the rule rather than the exception in small cetaceans. Assessment and management of small cetaceans must, therefore, be carried out on the stock level.

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2.3. Life History Parameters

It might be supposed that the odontocetes, being so much smaller than the mysticetes, have a higher rate of turnover of population. Such, however, may not be the case. The range of reproductive rates is from somewhat less than one calf per annum in small porpoises (Møhl-Hansen 1954) to one in 2–3 yr in pilot whales and white whales. This is the same range as shown by species of the genus *Balaenoptera*, ranging from the small minke whale to the large blue whale. The sperm whale, with one calf in 3½–4 yr, has the longest calving interval yet known for any whale.

The problem of determining growth rate is troubled by the difficulty of assessing whether one, or two, growth layers are laid down in the teeth annually, a problem parallel to that of determining the rate of deposition of growth layers in the ear plug of mysticetes. The number of growth layers accumulated in the lifetime of a delphinid ranges from at least 10 in small porpoises through 25–30 in dolphins such as *Stenella* to about 40 in pilot whales (*Globicephala*) and white whales (*Delphinapterus*). Sperm whales (*Physeter*) accumulate up to 70 growth layers and large Ziphiidae such as *Hyperoodon* are also long-lived. Longevity in odontocetes, therefore, appears to be, in part, a function of body size. It may also be a function of social structure. In some odontocetes (e.g. *Physeter*), not only are reproductive rates low, but age at sexual maturity is later in life so that productivity is extremely low.

While existing life tables are fragmentary, it seems likely that the low reproductive rates of most Odontoceti are associated with long parental care and highly social habits, acting to reduce mortality of young animals.

2.4. Feeding and Nutrition

The Odontoceti feed on fish and cephalopods, unlike the Mysticeti which in general feed on copepods, euphausiids, and small schooling fish. In general, therefore, the Odontoceti have a lower biological productivity than the Mysticeti. However, the Mysticeti are in general replaced by Odontoceti in warm seas, and here standing crops of pelagic Odontoceti (sperm whale, *Stenella* dolphins) may be high enough to provide significant yields of products for human use.

2.5. Pertinent Behavioral Features

Most small cetaceans are gregarious predators and have highly complex social systems. Schools in some species are segregated by sex and/or age. Management strategy must take this complexity into account. Such behavior may either facilitate exploitation of particular age/sex strata, or make it more difficult.

Also, the effects of disruption of social structure by fishing have not been investigated and may influence the abilities of populations of some species to withstand exploitation.

Analyses of catch per unit effort and availability must take into account the high capabilities of cetaceans to learn and accommodate. For example, reactions to harvesting vessels and research vessels used in density surveys may differ, depending on the past experiences of the particular stock. Many assumptions basic to classical fishery science must be reexamined in the context of cetacean behavioral and learning capacities.

2.6. Past and Present Exploitation

The rate of exploitation has varied greatly from species to species and from time to time. It is of prime importance to know the current level of exploitation in order to anticipate its effect upon the population. Data pertaining to past levels of exploitation are useful for estimating original population sizes and demonstrating trends in population levels as a result of exploitation or other factors. A few populations of small cetaceans have been heavily exploited, but the majority have not.

2.7. Possible Future Exploitation

Present trends indicate that future exploitation will be for meat products for human consumption in the small mysticetes, and harvesting of dolphins and porpoises in fisheries both for products (meat, oil, etc.) and incidentally, e.g. in the porpoise/tuna fishery of the eastern tropical Pacific, and in gillnet fisheries for fish.

2.8. Status of Stocks

The status of stocks of most small cetaceans, with the exception of very few species, is not known. Very little data has been collected to date. Stocks of many small ceta-

ceans are considered, however, to be at unexploited levels. There is evidence of depletion of stocks, e.g. in some definite localities such as inshore stocks of pilot whales in Newfoundland and narwhals in the northeast sector of Greenland. Other stocks with a long history of exploitation are apparently not depleted, e.g. pilot whales off the Faeroes.

2.9. Relation of Species to Habitat

In recent years much data has been gathered on the worldwide distribution and progressive concentration through trophic levels of organochlorinated pesticide residues, polychlorinated biphenyls, and heavy metals in marine ecosystems. Concentrations of these compounds are especially high in some coastal areas, and their evident accumulation in small cetaceans occurring in these areas should be viewed with concern. Also of importance is the development of the krill fishery in the Antarctic. These crustaceans are fundamental to the food chain of all baleen whales and many other animals in the Antarctic. In addition, many of the fish and squid stocks which are preyed upon by small cetaceans throughout the world are being fished at increasing rates by man. Other potential habitat factors that may affect small cetaceans, and that need to be studied and monitored are: boat traffic, air traffic (e.g. Mackenzie Delta), discarded pieces of fishing nets, and oil pollution, to mention some examples.

OUTLINE OF MINIMUM ITEMS FOR 2.1–2.9, IN SYSTEMATIC OVERVIEW

2.1. Systematics of Species

a. Complete scientific name
b. English common name
c. Distribution, with some ecological qualification, e.g. "cold water," "coastal," etc.

2.2. Number and Distribution of Stocks

a. Have stocks been identified?
b. Where?
c. Do other undescribed stocks probably exist?
d. Basis of separation (very briefly, with e.g. evidence from geography, morphology, biochemistry, tagging, etc.).

2.3. Life History Parameters

a. Age at sexual maturity
b. Calving interval
c. Other parameters, if conveniently available, e.g. longevity, breeding season, gestation, mortality coefficient(s), or qualitative statements on these items.

2.4. Feeding and Nutrition

a. Brief qualitative description of diet
b. Successfully maintained in captivity?

2.5. Pertinent Behavioral Features

a. Aspects of behavior relating to present or potential management problems, e.g. "easily trained (*Tursiops*)," "schools with tuna," etc.

2.6. Past and Present Exploitation

a. Where?
b. When?
c. How (methods)?
d. How many?

2.7. Possible Future Exploitation

a. Brief speculation (technology, rates of catch, etc.)

2.8. Status of Stocks

a. Population estimates
b. Trends in abundance

2.9. Relation of Species to Habitat

a. Pollution problems?
b. Habitat encroachment by man?
c. Other ecological considerations.

SYSTEMATIC OVERVIEW

Balaenoptera acutorostrata

Minke Whale

2.1. Systematics of Species

North Atlantic:

A single species is recognized, with all individuals having a white patch on the flipper, baleen white, sometimes with black streaking.

North Pacific:

A single species is recognized. All individuals in the population have a white patch on the flipper, baleen white, sometimes with black streaking.

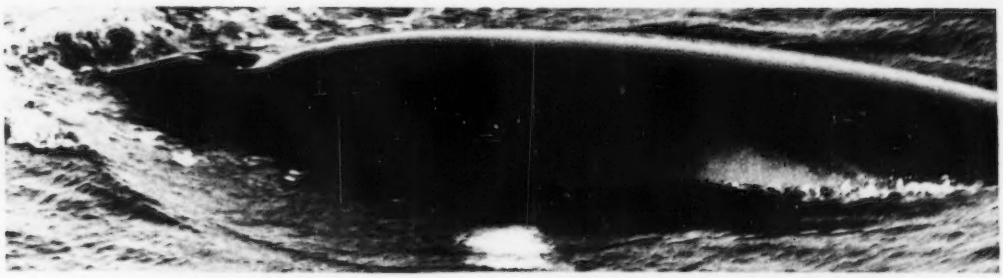

FIG. 1. Minke whale, *Balaenoptera acutorostrata*, as it approached and remained near a stationary ship off the south coast of Newfoundland on June 27, 1969. The blaze on the thorax, and the white flipper mark, visible under water, are characteristic of Northern Hemisphere minkes. (E. Mitchell photo 516:31.)

Southern Hemisphere:

A single species is provisionally recognized. Southern minke whales sampled in the Japanese fishery to date do not have a distinct white patch on the flipper. Some individuals from other areas in the Southern Hemisphere do have a distinct white patch, baleen dark grey but variable, some with white plates anteriorly, often with white inner edges (See note 1, Appendix B; Mitchell and Kozicki, this volume).

2.2. Number and Distribution of Stocks

North Atlantic:

Based on length-frequency distribution, Christensen (this volume) concluded that there is considerable difference between the catches in the Barents Sea and those in Greenland or Newfoundland. This may be due to the history of exploitation, with West Greenland and Newfoundland having a relatively short history of fishing. Some whale marking has been done in the North Atlantic but the number of tagged animals is very small, and to date only two tags have been recovered in the Norwegian coastal fishery.

North Atlantic minke whales seem to be mainly limited to continental shelf areas, with variation in density in different areas. This appears to be a reflection of the distribution of the prey species. Pelagic whale sighting programs should be expanded, however, as data is limited.

North Pacific:

Omura and Sakiura (1956) postulated that there are two different stocks of minke whales in the waters around Japan; the Sea of Japan stock, and the North Pacific stock. The distribution of minke whales in summer months is similar to that of fin whales, that is, whales are sighted throughout the North Pacific Ocean basin. Winter sightings are in far lower latitudes, mainly 20–25°N.

Southern Hemisphere:

There is no information on the existence of separate stocks of the minke whale in the Southern Hemisphere. Some whale marking has been carried out, but few whales have been tagged. Distribution of minke whales in the Antarctic is pelagic and circumpolar, but some areas have not been searched extensively. Northernmost distribution reaches to the tropical South Atlantic, Indian, and South Pacific oceans.

2.3. Life History Parameters

North Atlantic:

Many of these parameters are from Mitchell (1974) and Mitchell and Kozicki (this volume) (see also Jonsgaard 1955, 1962).

Sexual maturity in the sexes is: females = 24 ft (730 cm), males = 23 ft (700 cm).

The ovulation rate cannot be determined with great accuracy at present because of difficulties in determining the age of sampled animals. In the Newfoundland fishery, based on a limited sample, it was estimated to be 0.6 corpora per growth layer in the earplug.

The pregnancy rate in all sampled, sexually mature whales in all catching areas is very high (≈80%). This, however, may be due to a biassed sample, caused in part by regional segregation of mature females. Based upon data from catch areas only, minke whales appear to have a calving interval slightly in excess of 1 yr.

The length at birth is given as 9 ft (280 cm) by Jonsgaard (1951) and by Stevenson

(1951), and 8–9 ft (240–280 cm) by Sergeant (1963).

A growth curve and age-length key has been determined for females in the limited Newfoundland sample. On the basis of von Bertalanffy growth curve:

$$L_t = L_\infty - (L_\infty - L_o)e^{-k(t-t_o)}$$

The parameters for minke whale are:

$L_\infty = 25$ ft (760 cm)
$k = 0.25$
$t_o = 3.2$
$L_o = 14$ ft (430 cm)

Longevity cannot be determined at present, but the oldest whale in the Newfoundland sample had 14 growth layers in the earplug.

Analysis of samples collected is in progress, to study frequency of ovulation and rate of deposition of earplug laminae.

Most females have one calf. Occurrence of twins is estimated, on the basis of a small sample of whales, to be approximately 0.005.

The sex ratio of fetuses is close to 50%.

No natural mortality coefficient has been determined for minke whales in the North Atlantic at the present time.

For the Newfoundland catch, the age at sexual maturity for females was estimated to be approximately 7.0 growth layers, but the sample size is small.

The gestation period is 10–10½ mo.

Pairing season is spread over a period from December to May. The calving period is likewise spread over a period from October to March. The lactation period is estimated to be less than 6 mo.

North Pacific:

Sexual maturity in: females = 24 ft (730 cm), males = 22–23 ft (670–700 cm).

The ovulation rate of North Pacific minke whales is not available at present.

Calving interval — most minke whales give birth every year.

Length at birth is estimated at 280 cm (9 ft).

Growth curves and age-length keys have not been constructed.

Longevity cannot be stated at present.

Most females have one calf, the occurrence of twins is not known.

Sex ratio in fetuses is not known at present.

Natural mortality coefficient is not known.

Age at sexual maturity for females and males is not known.

Gestation period, about 10 mo.

Breeding season is spread over the whole year with two peaks, in January and June.

Calving season is accordingly spread with two peaks, in December and June.

Lactation period is not yet determined.

Southern hemisphere:

The main reference for these parameters are Ohsumi and Masaki (this volume) and references cited therein.

Sexual maturity in: females = 26 ft (790 cm), males = 24 ft (730 cm).

Ovulation rate was determined to be 0.87. Apparent pregnancy rate (number of pregnant females in the sample of sexually mature females) is 89.5% in the Antarctic.

Length at birth – no information.

Growth curve and age-length keys are available (Ohsumi and Masaki, this volume).

Longevity — among the whales sampled, there were animals with 50 growth layers, representing the maximum life span.

Sexual ratio of fetuses is 52% females, and it can be assumed to be 1:1.

Litter size — 0.0065 of the pregnant females examined had twins.

Natural mortality coefficient of sexually mature females is estimated to be 0.127. Average natural mortality coefficient for sexually immature females is 0.213.

Age at sexual maturity for females is estimated to be at 6.3 growth layers.

Gestation period is estimated to be about 10 mo.

Pairing season is spread over a very long period. The peak, if any exists, has not been determined as yet.

Calving interval — slightly in excess of 1 yr.

Lactation is estimated to be less than 6.0 mo.

2.4. Feeding and nutrition

North Atlantic:

Capelin (*Mallotus villosus*) is by far the predominant prey species in Newfoundland, the Barents Sea, and East Greenland. In 1 yr's sample from West Greenland, sand lance (*Ammodytes* spp.) was the dominant prey species. Other species of fish as well as krill and squid are taken by minke whales.

North Pacific:

Krill, and copepods, as well as fish such as

sand lance and anchovy (*Engraulis mordax*), are among the prey species.

Southern Hemisphere:

Euphausia superba is the dominant prey species. Other species of zooplankton, such as *E. spinifere* and *Calanus tonsus*, are also taken at times in the Antarctic (Ohsumi et al. 1970).

2.5. Pertinent Behavioral Features

North Atlantic:

Animals have frequently been observed to approach vessels closely. Observations to date indicate that mainly younger individuals exhibit this behavior. Minke whales appear to be more solitary than other species of baleen whales. However, some large schools (in the low hundreds) have been observed in the Barents Sea (Christensen, personal communication).

There is some association of minke whales with large baleen whales such as fin and blue. Throughout the North Atlantic there is apparently pronounced sexual segregation, as well as segregation by age-classes.

North Pacific:

On three occasions, adult minke whales were captured and maintained alive, one for 37 days and one for 3 mo (Kimura and Nemoto 1956). In 1937 a captive minke whale was maintained in the Mito Natural Aquarium in Japan. It was fed on dead sardines. A second minke whale was kept in the same aquarium in 1955, but escaped after about 37 days. The third, a calf, was kept two weeks when it died. In southern California, minke whales tend to approach ships.

Southern Hemisphere:

The largest school reported was comprised of 100 animals. The most frequently observed school size was two animals. Minke whales appear to be more solitary than other species of baleen whales in that area.

Of all baleen whales in the Antarctic, minke whales are found closest to the ice edge, frequently penetrating the ice fields. As in other areas, minke whales sometimes become entrapped in ice fields and may die (Taylor 1957).

On occasion, minke whales have been observed to approach catcher boats, as was demonstrated during research cruises (e.g. Kasuya and Ichihara 1965). There is very pronounced sexual and age segregation, and younger whales do not migrate to higher latitudes. Furthermore, there are seasonal fluctuations within these groups.

2.6. Past and Present Exploitation

North Atlantic:

Catching of minke whales began in Norway in the late 1920s;
in the Barents Sea and the Faeroe Islands after World War II;
in East Greenland in 1960;
in West Greenland in 1969; and
in Newfoundland in 1947.

Catches by Norwegians, up to 1973, were:

Coast of Norway (approximately)	52,781
Barents Sea	30,037
East Greenland and northwest Iceland	2,655
Shetland and Faeroe islands	6,534
East Iceland and Jan Mayen	776
West Greenland and Davis Strait	988
Coast of Labrador	11
Newfoundland	137
Newfoundland (by Canadians from IWS; approximately)	713

There is a catch of minke whales in Iceland (35 in 1972, reported in IWS) and Greenland (738 whales reported in IWS for the period 1959–71). These figures should be taken as the minimum.

Only small catcher boats are involved in the minke whale fishery in the North Atlantic. An experimental factory-catcher boat from Norway was introduced to this fishery but is no longer in use.

The catches in East and West Greenland have been increasing in the past few years (see Kapel this volume, and Kapel *in* Mitchell 1975, p. 20, 22). The Canadian catch is zero, as whaling was stopped in Canada in 1972. Norwegian fishing in the Labrador Sea and Grand Banks area has ceased for the moment.

North Pacific:

The exploitation of minke whales in the coastal waters of Japan began some centuries ago. From the 1920s, motor-catcher boats have been involved in expanding the fishery. Presently, the yearly catch is 200–400. The pelagic catch is very small (in the low tens). The catch in British Columbia was negligible, and is zero at present. There are no cumulative catch data from the coastal fishery in Japan for the period before 1948, and for

years 1948–72, the total catch was 3494 whales.

Bowen (1974) reported a catch of 715 minke whales in 1970 by the Republic of Korea.

A small type of catcher boat is used exclusively in the coastal waters of Japan as large catchers are not permitted to take minke whales. In the pelagic fishery, large catcher boats and factory ships are employed. (See Ohsumi, this volume.)

Southern Hemisphere:

Exploitation of Antarctic minke whales dates to the early 1950s. The total taken in the period 1951–52 to 1968–69 was 1886. A full catch operation was started, and 3021 whales were caught in 1971–72 season; 5745 whales were caught in 1972–73.

The Brazilian catch (as reported in IWS) was 4346 whales in the period 1955–72.

African catches were:

Cape Province, 12 (for period 1963–67); and Natal, 587 (for the period 1964–71).

There were catches in 1973–74 but figures are not available at the time of this writing.

2.7. Possible Future Exploitation

North Atlantic:

Assessment of stock size is being carried out and as soon as it is presented, final conclusions can be drawn on future exploitation. At present a provisional catch analysis suggests that "the present catch in the Barents Sea may be lower than the present sustainable yield of stock of minke whales in this area" (Christensen, this volume).

Future exploitation of the Newfoundland and other possible coastal stocks of minke whales cannot be foreseen as there is at present a total ban on any commercial whaling in Canada.

North Pacific:

Future exploitation depends on the result of assessment of stock size.

Southern Hemisphere:

Much work and discussion is being carried out in the International Whaling Commission on management and regulation of the Antarctic minke whale population.

2.8. Status of Stocks

North Atlantic:

Not known at this time, but a study by Jonsgaard and others should be completed by June 1974 (see IWC/SC26/14).

North Pacific:

There is no evidence from the coastal fishery of a decrease in the minke whale population (see Ohsumi, this volume).

Southern Hemisphere:

Again, this is being discussed in the International Whaling Commission sessions (see Ohsumi et al 1970; and particularly Masaki 1973, an estimate of 150,200 minke whales south of 30°S in summer, from sighting data). (See a subsequent estimate of 299,000 by Ohsumi and Masaki 1974.)

2.9. Relation of stocks to habitat

North Atlantic:

No habitat encroachment by man can be reported with the possible exception of a rapidly developing capelin fishery off Newfoundland. Minkes have been taken with portions of trawl netting embedded in their snout, indicating that they may enter such nets (? pair trawls) after approaching vessels, or that they become entangled in discarded netting.

North Pacific:

There are reports of minke whale entrapment in fixed fish nets along the coast of Japan.

Southern Hemisphere:

The developing krill fishery in the Antarctic may have an influence on the population of all baleen whales in that area.

Caperea marginata

Pigmy Right Whale

2.1 Systematics of Species

A single species is recognized.

2.2. Number and Distribution of Stocks

Pigmy right whales inhabit waters of the Southern Hemisphere only, north of the Antarctic Convergence. Most records (totaling about 71 individuals) are from the waters surrounding the following areas:

Tasmania
Southern New Zealand
Southeastern and southwestern Australia
South Africa
Argentina (doubtful)

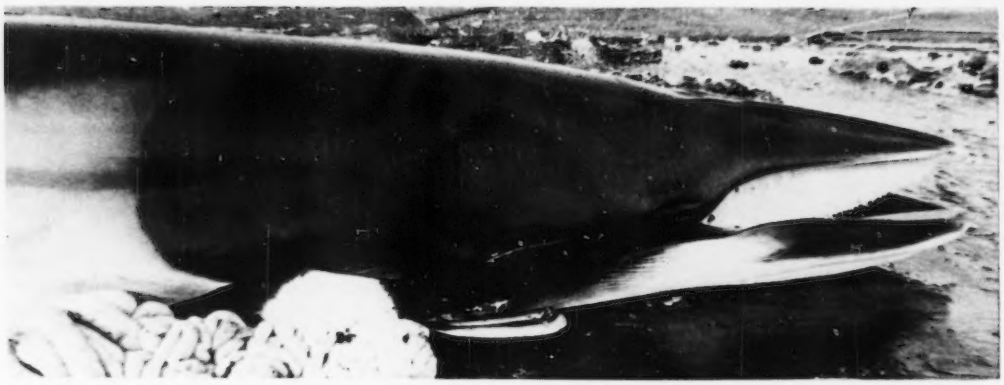

FIG. 2. Female minke whale, *Balaenoptera acutorostrata* 20 ft (6.15 m) in length, landed at South Dildo whaling station, Trinity Bay, Nfld. on June 19, 1971. White patch on flipper is visible above entrails; white baleen, blaze on thorax, and pointed snout are other field marks useful in identifying species at sea. (See article by Mitchell and Kozicki in this volume.) (Whale D65, B. Peers photo EDM–DR63:3.)

Chile (doubtful)
Falkland Islands

Pelagic sightings have been reported as well.

The temperature of waters inhabited by these whales ranges from 5 to 20 °C. The range of the pigmy right whale extends northward to subtropical waters of the South Atlantic (Ivashin et al. 1972).

Ross et al. (this volume) suggest that juveniles might tend to migrate to inshore waters in spring and summer, in South Africa.

2.3. Life History Parameters

Very little is known on this subject. Females measuring 637 and 621 cm were examined and found pregnant. The 621-cm specimen, taken on October 4, 1970 by the USSR, had 10 corpora in both ovaries.

The breeding season cannot be determined, but two females taken in June and October had fetuses 60 and 24.2 cm long, respectively.

2.4. Feeding and Nutrition

Calanus sp. was found in the stomach of two individuals examined, captured pelagically.

2.5. Pertinent Behavioral Features

One speculation is that the pigmy right whale is a very long diver and actually lies on the bottom (Davies and Guiler 1957). Schools of up to eight animals have been observed. Association with dolphins, and with a female sei whale with a calf, was reported by Ivashin et al. (1972). Hector (1875) described a female pigmy right whale captured in a large group of pilot whales (*G. melaena*). Ivashin et al. (1972) pointed out that sightings at sea of pigmy right whales may often be confused with minke whales, even by trained observers (and see Ross et al., this volume).

2.6. Past and Present Exploitation

There are no records of exploitation of pigmy right whales. The species is under protection at present by the IWC.

2.7. Possible Future Exploitation

Not known.

2.8. Status of Stocks

Not known.

2.9. Relation of Species to Habitat

Not known.

Tasmacetus shepherdi

Shepherd's Beaked Whale

2.1. Systematics of Species

The single species is known from eight

specimens from the southern hemisphere. It has been reported from New Zealand, Argentina, and Chile, suggesting a circumpolar distribution in southern temperate oceans.

2.2. Number and Distribution of Stocks

No data.

2.3. Life History Parameters

Females attain a length of at least 660 cm. There is no reliable data for males. The 660-cm female was sexually mature. No other data.

2.4. Feeding and Nutrition

A single, stranded specimen was examined for stomach contents, and contained primarily bottom fishes.

2.5. Pertinent Behavioral Features

This species has not been observed alive.

2.6. Past and Present Exploitation

No known catches of this species.

2.7. Possible Future Exploitation

No indication of possible exploitation.

2.8. Status of Stocks

No available information.

2.9. Relation of Species to Habitat

No available information.

Berardius arnuxii

Arnoux's Beaked Whale

2.1. Systematics of Species

This species is known only from a small number of specimens or at sea observations scattered throughout the southern oceans mainly from New Zealand but also from South Australia, Argentina, Falkland Islands, South Africa, South Georgia, South Shetlands, and the Antarctic Peninsula (Brownell 1974).

2.2. Number and Distribution of Stocks

No separate stocks have been identified.

2.3. Life History Parameters

Nothing is known about the biology of this species. The largest specimen recorded was a female 975 cm (32 ft).

2.4. Feeding and Nutrition

This species penetrates the ice fields and may sometimes become entrapped.

2.5. Pertinent Behavioral Features

Nothing is known.

2.6. Past and Present Exploitation

Rarely taken in Antarctic.

2.7. Possible Future Exploitation

No plans for future exploitation are known.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

No information.

Berardius bairdii

Baird's Beaked Whale

2.1. Systematics of Species

One species is recognized, limited to the North Pacific. (See note 2, Appendix B.)

2.2. Number and Distribution of Stocks

This species is found mainly in the offshore (deeper than 1000 m) waters of the North Pacific, from the Pribilof Islands and Alaska, south to southern Californian waters in the east, and from Kamchatka and the Sea of Okhotsk to southeast Japan in the west. No separate stocks have been identified.

2.3. Life History Parameters

a. age at first reproduction: no data

b. calving interval: no data, probably about 3 yr

c. other: length at birth is about 15 feet (4.57 m); sexual maturity is reached between 32 and 36 ft (9.8 and 10.9 m) in males. There is less data for females: A 29-ft (8.8-m) animal was immature and a 37-ft

FIG. 3. A 33-ft (10.1 m) male Baird's beaked whale, *Berardius bairdii*, caught off the northwest coast of Vancouver Island, British Columbia in July of 1950. Only a few tens of these whales were caught off western Canada, and morphometric data showed them to be similar to those fished off Japan (Pike and MacAskie 1969). (See article by Ohsumi in this volume.) (Photograph of specimen 581, from Pike 1953.)

(11.2-m) animal was mature. The maximum reported length for males is 39 ft (11.8 m), for females 42 ft (12.8 m).

2.4. Feeding and Nutrition

This species feeds principally on deep-sea fish and squids (*Gonatus fabricii* and *Onychoteuthis* sp. have been reported from *B. bairdii* in the NE Pacific; Rice 1963), as well as crustaceans and sea cucumbers.

2.5. Pertinent Behavioral Features

Catches in both California and Japan consist mainly of males, and may indicate sexual segregation.

2.6. Past and Present Exploitation

The largest catches have been in Japanese waters, ranging from 76 to 322 per year, with maximum catches in the 1950s. The Canadian fishery took 13 from 1950 to 1958, the U.S. fishery (in California) took eight from 1959 to 1962, and the USSR has made very small catches, incidental to pelagic whaling.

2.7. Possible Future Exploitation

Catches have been decreasing in Japan and the other fisheries (with the possible exception of the USSR) are closed. There are no indications of future expansion of fisheries for this species.

2.8. Status of Stocks

Nishiwaki and Oguru (1971) indicated a steady decline in numbers caught off Japan, due to reduced catching effort and economic conditions. Catches in other areas have been so low as to have no probable effect on the stocks. Catch per unit of effort has been

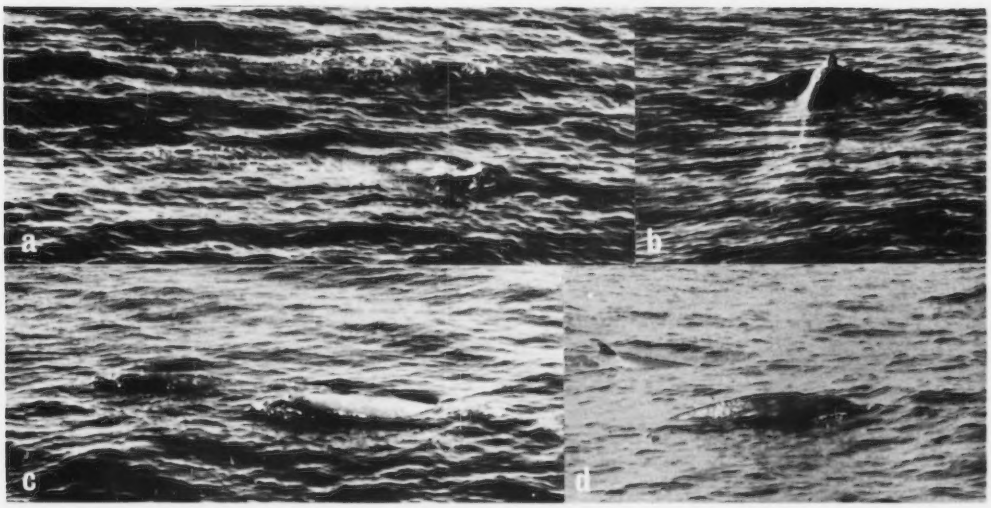

FIG. 4. Beaked whale, probably Blainville's beaked whale, *Mesoplodon densirostris*, observed at Pohai Bay, Oahu, Hawaii. The single, large tooth at the midlength of the lower jaw gives a characteristic profile, along with the long snout and small, posteriorly placed dorsal fin. Beaked whales are rarely observed and photographed in the wild. (Photographs by E. Shallenbarger, courtesy S. Leatherwood.)

almost constant between 1952 and 1972 (Ohsumi, this volume).

2.9. Relation of Species to Habitat

No data.

Mesoplodon spp.

Beaked Whales

M. pacificus
M. bidens
M. densirostris
M. europaeus
M. layardii
M. hectori
M. grayi
M. stejnegeri
M. bowdoini
M. mirus
M. ginkgodens
M. carlhubbsi

2.1. Systematics of Species

The species of *Mesoplodon* are at present based upon scanty material, and are consequently poorly defined. It is best to accept the above list (Moore 1966) with the reservation that thorough studies of sexual, age, and geographic variation may reduce the number of recognized species.

Some species have a wide distribution (e.g. *M. densirostris*, tropical and temperate seas of the world), while others are restricted to a single ocean basin (e.g. *M. stejnegeri*, North Pacific). (See note 3, Appendix B.)

2.2. Number and Distribution of Stocks

There is no information relating to stocks of *Mesoplodon* species.

2.3. Life History Parameters

Length at attainment of sexual maturity is known for a very few species, otherwise there is no information.

2.4. Feeding and Nutrition

This group is primarily cephalopod feeders, although a variety of fishes and salps are also eaten.

2.5. Pertinent Behavioral Features

Their distribution, coupled with apparently small population size and a tendency to avoid ships, has prevented them from being either studied or fished to any appreciable extent so

far as is known. In general they are oceanic forms, occurring in small groups.

2.6. Past and Present Exploitation

These species are rarely seen, but a few may be taken in any of the small whale fisheries, particularly those of Japan.

2.7. Possible Future Exploitation

Very low numbers will probably continue to be taken in multispecies, small whale fisheries. However, since these species are involved in multispecies fisheries, and a falling catch per unit effort would probably not influence future catch effort, it cannot be assumed that future exploitation will not be significant.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No information available.

Ziphius cavirostris

Cuvier's Beaked Whale

2.1. Systematics of Species

This species is cosmopolitan, occurring in all the oceans, with the exception of the high latitudes. It is known mainly from strandings, as far south as the Cape of Good Hope and Tierra del Fuego, and as far north as the Bering Sea. In the North Atlantic it has been reported as far north as the North Sea and Cape Cod, and northward to Alaska in the North Pacific.

2.2. Number and Distribution of Stocks

No data. Mitchell (1968) regarded all strandings in the northeast Pacific as representing one panmictic population.

2.3. Life History Parameters

a. age at sexual maturity: no data.

b. size at sexual maturity: males mature at a length of about 18 ft (5.4 m), females at 18–20 ft (6.1 m).

c. calving interval: no data.

d. other: length at birth between 200 cm and 10 ft (305 cm). The maximum lengths reported from Japan are 22 ft (6.7 m) for males and 23 ft (7.01 m) for females. A female 28 ft (8.5 m) long was reported from the Atlantic, but Moore (1968) has identified the specimen as *H. ampullatus*.

2.4. Feeding and Nutrition

Data on stomach contents from the Japanese fishery indicate that in some areas squid were the main food item, while elsewhere deep water fish predominated.

2.5. Pertinent Behavioral Features

No data. It is primarily an oceanic form, and has been reported traveling in small groups of three to five animals.

2.6. Past and Present Exploitation

This species is taken in small numbers in the Japanese small whale fishery (Omura et al. 1955; Omura 1972; Nishiwaki 1972). Catches from 1965 to 1970 ranged from 13 to 60. It has also been reported from the Lesser Antilles small whale fishery, where it is rarely taken. It has probably been taken on rare occasions by some of the small whale fisheries within its range.

2.7. Possible Future Exploitation

Small whale fisheries will probably continue to take small numbers of this species on an opportunity basis.

2.8. Status of Stocks

No data.

2.9. Relation of species to habitat

No data.

FIG. 5. Hubbs' beaked whale, *Mesoplodon carlhubbsi*, stranded April 28, 1962 in San Simeon Bay, San Luis Obispo County, Calif. Data on this 440-cm female was published by Roest (1964). Much of the knowledge of species of *Mesoplodon* is derived from beach stranded specimens such as this one. (Photographs by A. I. Roest.)

a
b
c

FIG. 6. Cuvier's beaked whale, *Ziphius cavirostris*, in the northeast Pacific. a, ?*Ziphius* off the west coast of Baja California, March 1971; b, *Z. cavirostris* off San Clemente Island, Calif., April 1974. This is a little-known species, taken in small numbers off Japan (see Omura 1972). (Photographs by S. Leatherwood; see Leatherwood et al. 1972, fig. 39.)

Hyperoodon ampullatus

Northern Bottlenose Whale

2.1. Systematics of Species

This species is distributed primarily in the high latitudes of the North Atlantic. It occurs north to the edge of the ice in the summer, south to New York, and Cape Verde in the winter. It is generally found in water deeper than 100 m. (See note 4, Appendix B.)

2.2. Number and Distribution of Stocks

There are local concentrations in the North Atlantic that may represent separate stocks (see Benjaminsen 1972), but there has been no definitive documentation of stock discreteness to date.

2.3. Life History Parameters

a. age at sexual maturity: 9–14 growth layers in teeth in females, 9–11 in males (see Christensen 1973).

b. calving interval: probably between 2 and 3 yr.

c. other: length at birth is about 10 ft (3.05 m), females are sexually mature at 22–23 ft (6.7–7.01 m) (minimum of 20 ft (6.1 m)), males at about 24 ft (7.3 m); gestation period is around 12 mo.

2.4. Feeding and Nutrition

The principal food item is the squid, *Gonatus fabricii*. Herring (*Clupea harengus*) are sometimes taken.

2.5. Pertinent Behavioral Features

There is some indication that males and females may segregate during migration. The species is known to approach ships. They are generally found in groups of two to five or more. Older males frequent more northern waters, close to the ice. Epimeletic behavior is known, and whalers exploit this behavior to their advantage.

2.6. Past and Present Exploitation

This species has been fished intensively for over a hundred years in the North Atlantic. Present fisheries for this species are primarily conducted by the Norwegians, along the coast

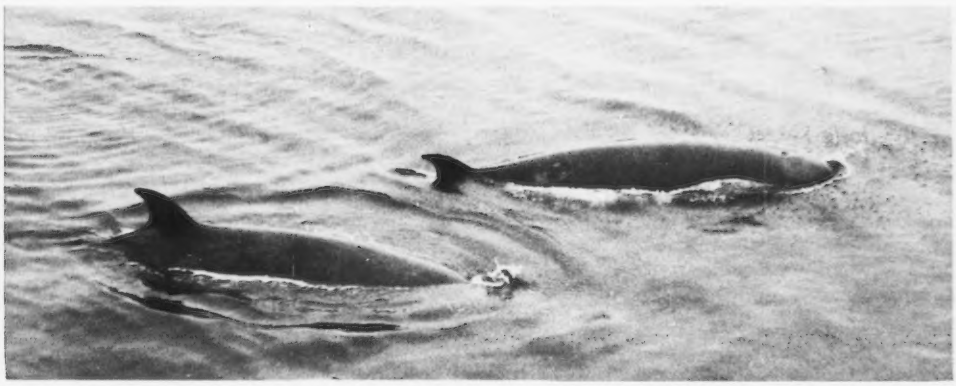

FIG. 7. Northern bottlenose whales, *Hyperoodon ampullatus*, approaching a research vessel off Cape Chidley, Labrador on June 17, 1969. A fishery for this North Atlantic species has been pursued for over 100 yr. (See papers by Mitchell and Kozicki, by Christensen, and by Foote, in this volume.) (E. Mitchell photo 462:87.)

of Norway, south and west of Spitzbergen, between Iceland and Jan Mayen Island, and recently in Davis Strait and off the Labrador coast. A few were taken by Canada off the coast of Nova Scotia in the 1960s (see also Mitchell and Kozicki, this volume). Total catches for the Norwegian fisheries have been nearly 700 in peak years. The Norwegian catch has decreased in recent years for economic reasons. Between 1938 and 1973, the Norwegians caught 4890 bottlenose whales outside Norwegian coastal waters (Christensen, this volume). This is in sharp contrast to peak annual catches of 2–3000 in the 1890s (Mitchell 1975).

2.7. Possible Future Exploitation

If the market value of products increases, the Norwegian catch may rise to its former levels. The Canadian fishery has been closed due to a total ban on whaling.

2.8. Status of Stocks

There are few population estimates, and little direct indication of depletion of stocks. Mitchell (1975, p. 50) gave a cumulative catch estimate of 25,796.

2.9. Relation of Stocks to Habitat

No available information.

Hyperoodon planifrons

Southern Bottlenose Whale

2.1. Systematics of Species

One species is known, circumpolar in the southern hemisphere. (See note 4, Appendix B.)

2.2. Number and Distribution of Stocks

Widespread in all southern oceans: along the shores of Argentina, Falkland Islands, Chile, Australia, New Zealand, South Africa, and near the coast of Antarctica in the Pacific and Indian Ocean sectors (Brownell 1974). No stocks have been identified.

2.3. Life History Parameters

The largest specimens known are a lactating female measuring 745 cm (Fraser 1964) and a male, 694 cm (Hale 1931).

2.4. Feeding and Nutrition

A stranded specimen in Australia had a large quantity of cephalopod beaks in its stomach (Hale 1931).

2.5. Pertinent Behavioral Features

None known.

2.6. Past and Present Exploitation

Rarely taken in Antarctic.

2.7. Possible Future Exploitation

None known.

2.8. Status of Stocks

Unexploited at present.

2.9. Relation of Species to Habitat

No information.

Kogia breviceps

Pygmy Sperm Whale

2.1. Systematics of Species

Distribution is mainly in tropical and warm temperate waters; it seems that this species is found in higher latitudes than *Kogia simus*.

2.2. Number and Distribution of Stocks

No data on number and distribution of stocks.

2.3. Life History Parameters

Almost nothing is known about the life history of this species. From the data available (Duguy 1966), there does not seem to be a distinct calving period. Pygmy sperm whales of southern Australia and New Zealand often were pregnant while lactating. There is a preliminary study (by van Bree et al. 1975) on growth and age in relation to tooth laminations. Some data on reproduction are referred to in Bryden (1972).

2.4. Feeding and Nutrition

Although pygmy sperm whales seem to feed mostly on cephalopods, they also take fishes (see Fitch and Brownell 1968).

2.5. Pertinent Behavioral Features

They seem to occur in small schools of three to six individuals and seem to be rather timid.

2.6. Past and Present Exploitation

Along the coast of southern Japan (Taiji), dwarf and pygmy sperm whales are taken by chance with hand harpoons at the rate of three to six every year. The inhabitants of the whaling villages in the Timor Sea (Indonesia; see Weber 1923) also hunted and may still hunt the two small species of sperm whales. Nothing can be said about the numbers caught.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Kogia simus

Dwarf Sperm Whale

2.1. Systematics of Species

Distribution is mainly in tropical and subtropical waters. Until recently, the species had been confused with the sympatric *Kogia breviceps* (see Handley 1966). Therefore, no data exclusively on *Kogia simus* exist (with the exception of some data on stomach contents; see Fitch and Brownell 1968).

2.2. Number and Distribution of Stocks

No data.

2.3. Life History Parameters

Three males 245, 229 and 189 cm in total length were examined in July 1967 at Taiji, Japan; only the largest specimen was sexually mature (Harrison et al. 1972).

FIG. 8. Dwarf sperm whale, *Kogia simus*, stranded on the California coast in February 1967. This small whale and its close relative, the pygmy sperm whale, *Kogia breviceps*, may have been exploited extensively by early whalers. (See Roest, 1970; photograph courtesy A. I. Roest.)

2.4. Feeding and Nutrition

No data.

2.5. Pertinent Behavioral Features

No data.

2.6. Past and Present Exploitation

No data.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Monodon monoceros

Narwhal

2.1. Systematics of Species

One species is known.

2.2. Number and Distribution of Stocks

Distribution: high arctic, mainly in deep water, absent from north Siberian shelf and rare in north Alaskan sector. Stocks have not been distinguished.

2.3. Life History Parameters

Birth probably occurs around mid-July and conception around mid-April. With gestation 15 mo, and if lactation lasts 20 mo, as with the white whale, calving could occur every 3 yr (Mansfield et al., this volume).

2.4. Feeding and Nutrition

Squid beaks and polar cod (*Boreogadus saida*) were found in stomachs at Koluktoo Bay (Mansfield et al., this volume) and Greenland halibut, polar cod, and shrimp at West Greenland (F. Bruemmer unpublished data; Vibe 1950).

2.5. Pertinent Behavioral Features

Usually in small groups of up to about 10 individuals. Twice kept in captivity, but not successfully maintained (see e.g. Newman 1970 for the Vancouver work).

2.6. Past and Present Exploitation

Catches reported in 1962–71 in Canadian arctic averaged 113 per year which should probably be doubled to allow for loss due to sinking. The animals are taken by first shooting and then harpooning (Bruemmer 1966). (See Kapel, this volume, and in Mitchell 1975, p. 20, for catches in Greenland; and see Fig. 40.)

2.7. Possible Future Exploitation

Under present Canadian regulations, the potential annual catch could reach double the annual production. It is thus necessary to review regulations.

2.8. Status of Stocks

A conservative estimate for northern Canada and northwestern Greenland is 10,000 where it appears that the maximum potential annual kill is above the annual production (Mansfield et al., this volume). Status on east Greenland coast believed good. Has apparently disappeared from northeast sector of range (Novaya Zemlya, Franz Josef Land) according to Tomilin (1957), presumably due to hunting.

2.9. Relation of Species to Habitat

There is potential disturbance of traditional narwhal summer areas by heavy hunting and commercial activities or both. The Inuit at West Greenland have forbidden the use of motor boats in narwhal hunting areas during summer months.

Delphinapterus leucas

White Whale

2.1. Systematics of Species

Distribution is arctic and subarctic, shallow water and estuarine for the single recognized species.

2.2. Number and Distribution of Stocks

The Gulf of St. Lawrence stock is geographically separated from others; that in Hudson's Bay separate from others as evidenced by tagging data and size distributions.

Eastern Baffin Island (Cumberland Sound) stock appears to be isolated, from evidence of local depletion. Stocks in the White Sea probably separate from those in the Barents and Kara Sea. Possibly separate stocks in south Alaska, the Beaufort Sea, and the Bering Sea. (See Sergeant, this volume; and Kleinenberg et al. 1964.)

2.3. Life History Parameters

a. age at sexual maturity: based on two growth layers per annum — 5 yr for female and 8–9 yr for male.

b. calving interval: once very 2–3 yr (Sergeant 1973; Brodie 1971).

c. other: longevity 25 yr, based on two dentinal growth layers per annum; mating in spring; calving in summer, and this is progressively later further north; gestation is 14 mo; natural mortality low.

2.4. Feeding and Nutrition

a. wide spectrum of shallow-water benthos, e.g. decapod crustaceans, cephalopods and schooling fish (e.g. *Boreogadus*; see Vladykov 1944; Sergeant 1973; Kleinenberg et al. 1964).

Beluga are successfully maintained in captivity (New York, Vancouver, Duisburg, etc.); once they survive an initially high mortality after capture.

2.5. Pertinent Behavioral Features

Calving seems to occur in river mouths with warm temperatures (10–17 °C). Concentrations occur in places where they are vulnerable to exploitation in summer. Herding behavior facilitates drive fisheries and entrapment.

2.6. Past and Present Exploitation

Have been exploited over almost entire range with a recent decline in catches in Canada (Sergeant, this volume), Alaska (Anon. 1973, p. 20592), and probably in USSR. Annual world landings of 4800–6200 (Kleinenberg et al. 1964). For landings at Spitzbergen see Lønø and Øynes (1961). Several catching methods have been used, see summary by Kleinenberg et al. (1964). (For catches in Greenland, see Kapel, this volume, and Kapel *in* Mitchell 1975, p. 20.)

2.7. Possible Future Exploitation

Although trends are presently towards decreased utilization, causes appear to be primarily social and economic, not from overfishing.

2.8. Status of Stocks

Sergeant (this volume) assessed the arctic Canada populations at 30,000 or more. The only stock that is apparently depleted is that in Cumberland Sound.

The stocks off Alaska have been estimated at 300–500 (Cook Inlet), 1000–1500 (Bristol Bay), and a larger population north of Bristol Bay. Sergeant (this volume) estimated 4500 in a Beaufort Sea population.

2.9. Relation of Species to Habitat

a. Mercury levels are presently over 0.5 ppm wet weight in the Canadian arctic, so that the meat cannot be marketed for human consumption (Sergeant, this volume).

b. There is disturbance from boat and air traffic, and from the creation of artificial islands by oil companies in the Mackenzie Delta. There is potential for disturbance in the development of ports or construction of gas pipelines in the Canadian arctic (Sergeant, this volume).

Steno bredanensis

Rough-Toothed Dolphin

2.1. Systematics of Species

A single species is presently recognized.

2.2. Number and Distribution of Stocks.

Distribution in tropical and subtropical waters, occasionally a few animals have stranded in colder water areas outside their normal range. Seems to occur also in the Mediterranean in small numbers.

There are indications that there are differences (e.g. length of the rostrum) between stocks in the Atlantic and in the Indo-Pacific.

2.3. Life History Parameters

There is almost no published data on this subject. A pregnant female was 235 cm in length. Lengths of full-grown specimens in the Atlantic range between 223 and 275 cm.

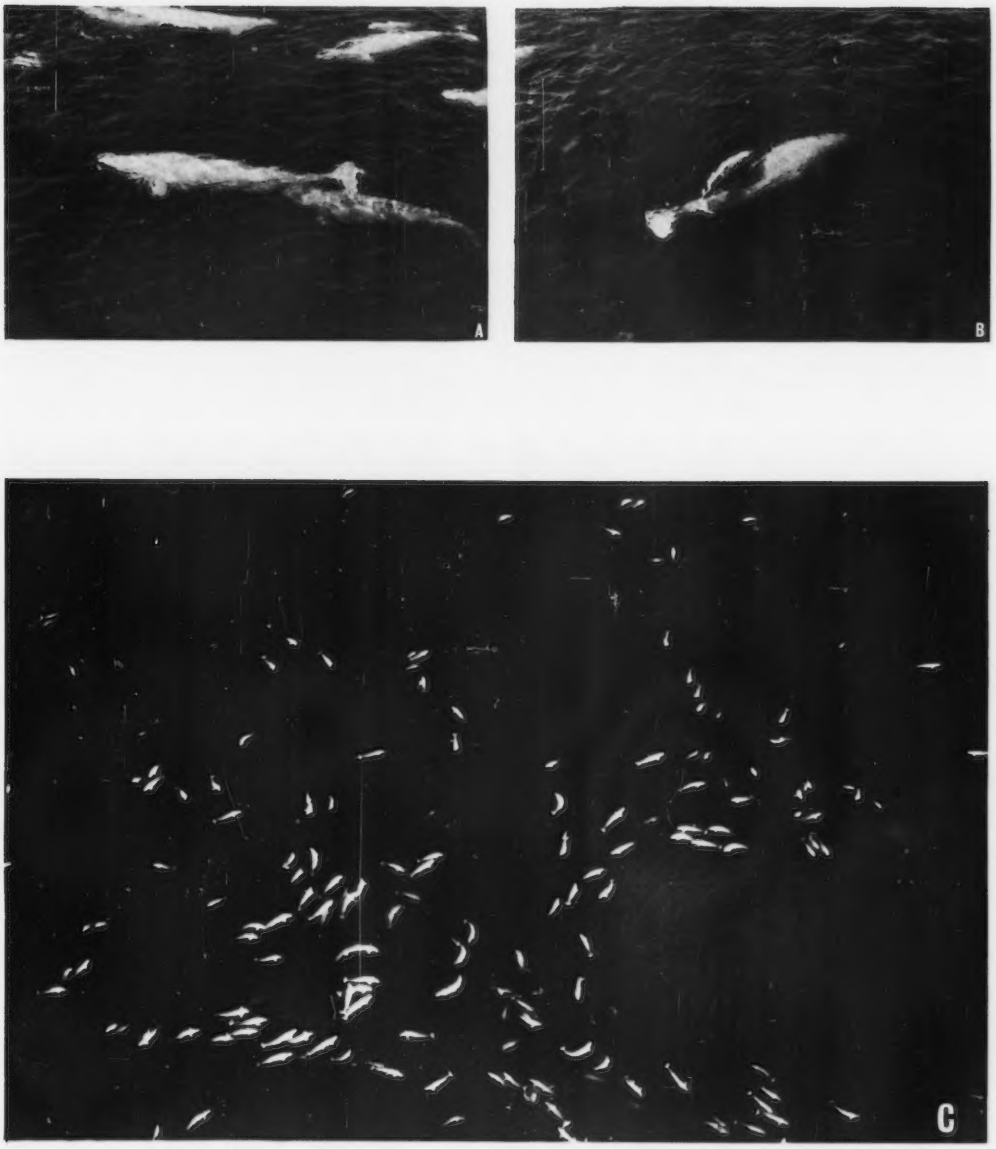

FIG. 9. Beluga or white whale, *Delphinapterus leucas*, at Cunningham Inlet, Somerset Island, Northwest Territories, Canada. a, An older calf attempting to nurse. Some large white females had a neonatal calf and a larger grey or brown calf, but the association with the older calf was considerably looser than with the neonate (August 6, 1974); b, a neonatal calf being supported by its mother, nudging it to the surface to breathe; neonates are initially fairly light in color, but darken somewhat during the first season (August 5, 1974); c, an aerial view of a section of the Cunningham Inlet herd; the population of this Inlet on August 6–7, 1974 peaked at somewhat in excess of 1000 animals. (See paper by Sergeant, this volume.) (Photographs by K. Hay (b) and R. McClung (a, c), courtesy of D. E. Sergeant.)

Some data on life history parameters apparently have been collected at the oceanarium in Hawaii.

2.4. Feeding and Nutrition

Few data on diet are available. Most probably feed on fishes. In the stomachs of some specimens stranded in Florida, pelagic octopus were found (Layne 1965). The species has been kept successfully in captivity in Hawaii and in Japan.

2.5. Pertinent Behavioral Features

Easily trained — seems to be more "intelligent" than bottlenose dolphins. In Hawaii, an animal crossed with a bottlenose dolphin; a healthy hybrid was born and, as far as is known, is still living. Rarely, it schools with tuna (see Perrin, this volume). It seems to occur from time to time in schools of bottlenose dolphins. A number of mass strandings are known.

2.6. Past and Present Exploitation

No data, except that small numbers are taken in Japanese waters. Animals from mass strandings in Senegal were used for human consumption. Also involved in tuna fishery, eastern tropical Pacific in small numbers.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

FIG. 10. Rough-toothed dolphin, *Steno bredanensis*, in captivity at Sea Life Park in Hawaii. This is a tropical, pelagic species, seldom taken in fisheries. (Photograph by S. Leatherwood.)

2.9. Relation of Species to Habitat

No data.

Sotalia fluviatilis

Tucuxi

2.1. Systematics of Species

Distribution along the coast of South America from Santos in the south to Lake Maracaibo in the north. May be found also along the coast of Atlantic Central America (van Bree, personal communication). Coastal animals enter rivers (e.g. in Surinam and Guyana). A large population, in contact with the coastal population, occurs in the Amazon and its tributaries, up to the Andes. It is said that the species also lives in the rivers of Venezuela, but during a recent visit to that country, van Bree (1974) could not confirm its occurrence. In the Orinoco River it ranges upstream to Ciudad Bolivar. (See note 5, Annex B.)

2.2. Number and Distribution of Stocks

Although there are almost no data available, there may be two separate subpopulations; one freshwater and one marine. The main differences are in the total lengths of full-grown specimens (small in the Amazon) and the color (lighter colored in the Amazon). They are rather common off the coast of Surinam, off the coast between Rio de Janeiro and Santos, as also in some localities in the Amazon River basin.

2.3. Life History Parameters

Harrison and Brownell (1971) reported that a sexually mature female from the Amazon had a length of 146 cm; a sexually mature male from the same locality had a length of 148 cm. Schenkkan, van Utrecht, and van Bree (unpublished data) noted greater lengths in sexually mature specimens from Surinam coastal waters. De Carvalho (1963) noted greater lengths in specimens off the Brazilian coast.

2.4. Feeding and Nutrition

Analyses of stomach contents of animals from Surinam showed that the dolphins fed mainly on armoured catfishes — some crustaceans (prawns and crabs) were also found. This hard-shelled prey may be the reason

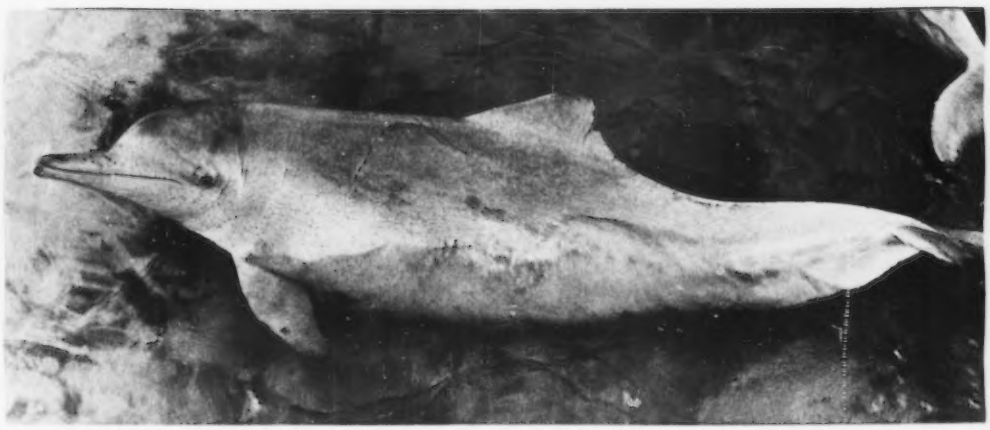

FIG. 11. The Indo-Pacific hump-backed dolphin, *Sousa* cf. *S. borneensis* (= *Sousa chinensis* of this report), was originally described from Sarawak. This species is relatively common along northeastern Australia where it occurs close to the coast and penetrates estuarine areas. There are reports of these animals heaving themselves over banks when the water is very shallow at low tide. They are kept in captivity in two Queensland oceanaria at present. (Photograph courtesy W. H. Dawbin.)

that the dolphins (even the young ones) had teeth mostly worn-down. De Carvalho (1963) mentions other fish species. It has been kept successfully in captivity in the USA and in Santos, Brazil, a few times.

2.5. Pertinent Behavioral Features

Almost no data. The species is not timid.

2.6. Past and Present Exploitation

In Surinam, specimens often are taken accidentally in driftnets in the mouths of the rivers. Along the coast of Brazil they are taken in gillnets.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Sousa chinensis

Indo-Pacific Hump-Backed Dolphin

2.1. Systematics of Species

Distribution is from near Cape of Good Hope along the coast of east Africa to the north, in the Red Sea to the mouth of the Suez Canal, along the Arabian Gulf, in the Persian Gulf, along the coast of the Indian subcontinent, in Indonesian waters to the middle of the west coast of Australia (Carnarvon); on the east coast of Australia near Sydney to the north, in New Guinea waters, Borneo north to the Indo-Chinese coast up to the Canton River. It is uncertain whether it occurs in Philippine coastal waters. (See note 6, Appendix B.)

2.2. Number and Distribution of Stocks

Subpopulations have been recognized (unknown whether these represent different stocks) by differences in color and markings. Along the African coast, often spotted (*S. lentiginosa*), in muddy (e.g. Indian) waters dark grey colored without spots (*S. plumbea*); young animals near Borneo (*S. borneensis*), on the east coast of Australia and along the south China coast very light colored (cream colored). Southernmost populations seem to migrate to the north in winter.

2.3. Life History Parameters

No data.

2.4. Feeding and Nutrition

No published data. Seems to feed on fishes.

Has successfully been kept in captivity in oceanaria near Sydney and Brisbane for some time (D. Brown personal communication). Also has been in captivity in Port Elizabeth.

2.5. Pertinent Behavioral Features

No published data.

2.6. Past and Present Exploitation

Along the Arabian Sea, in the Red Sea, and in the Persian Gulf small numbers of this species of dolphin have been taken by fishermen and used for human consumption. Exact data are lacking. (See Bruyns, 1960.)

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Sousa teuszii

Atlantic Hump-Backed Dolphin

2.1. Systematics of Species

Distribution: originally discovered in the harbor of Douala, Cameroons. The species has been found regularly in Senegal coastal waters. Recently some specimens were sighted and collected on the coast of Mauritania (Busnel 1973; Fraser 1973). In view of its known range, one may expect that the species occurs along the west African coast from Mauritania in the north to Angola in the south. (See note 6, Appendix B.)

2.2. Number and Distribution of Stocks

No data. It seems that in coastal waters of southern Senegal it is rather common.

2.3. Life History Parameters

No data.

2.4. Feeding and Nutrition

In the specimen first discovered some plant material (among it mangrove seedlings) was found. It is almost certain that this material had been swallowed accidentally. Cadenat (1959) lists the fish genera *Ethmalosa* and *Mugil* as taken. The last one is also mentioned by Busnel (1973) for Mauritania. As far as is known, it has never been kept in captivity.

2.5. Pertinent Behavioral Features

No data.

2.6. Past and Present Exploitation

Specimens have been taken by beach seines and shark nets in Senegal waters.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Orcaella brevirostris

Irrawaddy Dolphin

2.1. Systematics of Species

Distribution is from the Bay of Bengal to North Australia (Indonesian Waters) and from North Australia (e.g. Anon. 1966) to coastal waters of Indo-China. It seems to live only in warm, tropical waters, but enters large rivers and can live permanently in fresh water. (See also Thomas 1892; Bruyns 1966.) (See note 7, Appendix B.)

2.2. Number and Distribution of Stocks

No data.

2.3. Life History Parameters

What is known about the species (together with some new data) has been summarized in a thesis by R. Lloze (1973).

2.4. Feeding and Nutrition

According to unconfirmed reports, the species feeds not only on fishes, but also on crustaceans.

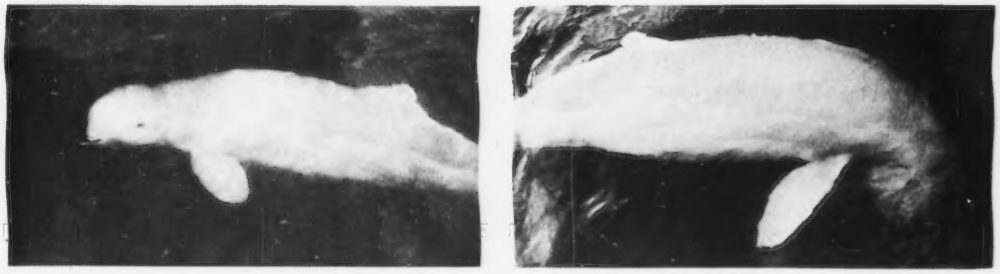

FIG. 12. The known range of the Irrawaddy dolphin, *Orcaella brevirostris*, has in recent years become extended to include Papua-New Guinea and the coast of Queensland. It goes 10 or more miles upstream in rivers of Papua and is well enough known locally to have names given by Papuas. It is a relatively slow mover but has a very great flexibility of neck and tail. Specimens have been kept successfully in captivity at Cairns. (Photographs courtesy of W. H. Dawbin.)

2.5. Pertinent Behavioral Features

No data.

2.6. Past and Present Exploitation

As far as is known, the species is not hunted and is only accidentally taken in anti-shark nets (e.g. recently at the northern end of the Great Barrier Reef).

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Peponocephala electra

Melon-Headed Whale

2.1. Systematics of Species

Distribution is in tropical and warm temperate waters; only one species is recognized.

2.2. Number and Distribution of Stocks

No data.

2.3. Life History Parameters

Almost no data. In the Pacific, newborn specimens have been found in June (Nishiwaki and Norris 1966), and very young specimens in August (Dawbin et al. 1970). What is known about size and growth has been cited by van Bree and Cadenat (1968) and by Dawbin et al. (1970). Goodwin (1945) reported a sexually mature male 273 cm long.

2.4. Feeding and Nutrition

No data.

2.5. Pertinent Behavioral Features

No data. Most probably a social species living in schools of about 100–200 individuals in view of the mass strandings. It appears that, as in some other delphinids, they often surface in a vertical position to look around above water.

2.6. Past and Present Exploitation

About 250 individuals of a school of about 500 animals were driven ashore in Japan (Suruga Bay), in 1965 and were used for human consumption. Meat of specimens from an Australian mass stranding was used as bait in lobster traps.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Feresa attenuata

Pygmy Killer Whale

2.1. Systematics of Species

Distribution is in tropical and warm temperate waters; only one species is recognized.

2.2. Number and Distribution of Stocks

No data.

2.3. Life History Parameters

Little data. An early juvenile, possibly newborn, was 82.2 cm in length when captured in May 1967 off Costa Rica (Perrin and Hubbs 1969). Pryor et al. (1965) reported a 216 cm sexually mature male. Lengths of 7 males and 7 females from Japan were 214–244 cm and 208–227 cm, respectively (Nishiwaki et al. 1965). Two of these females (221 and 227 cm) were pregnant.

2.4. Feeding and Nutrition

No data. It is reported (Best 1970) that the species attacks other species of dolphins. Specimens kept in captivity in Japan died soon.

2.5. Pertinent Behavioral Features

A captive pygmy killer whale in Hawaii showed aggressive behavior. Other dolphins kept together with *Feresa* in Japan showed clear fright reactions.

2.6. Past and Present Exploitation

Almost no data. Specimens from the Atlantic and the Pacific have been taken accidentally in nets. Those few (13) captured in the Sagami Bay in Japan were driven to the shore with the intention to use them for human consumption. Taken incidentally in small numbers in the tuna fishery of the eastern tropical Pacific (Perrin and Hubbs 1969).

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Pseudorca crassidens

False Killer Whale

2.1. Systematics of Species

Distribution is in tropical and warm temperate waters (among them the Mediterranean); normally offshore. May exceptionally wander to colder waters. A single species is recognized.

2.2. Number and Distribution of Stocks

No data. From the paper by Mörzer Bruyns (1969), it appears that subpopulations exist in the Indian Ocean.

2.3. Life History Parameters

Little data published. Comrie and Adam (1938) described ovaries from four sexually mature females that ranged in length from 425 to 450 cm. A 109 cm fetus was found in the 425 cm animal. Dr. P. E. Purves of the British Museum (Natural History), London, has a large study on this subject ready for publication.

2.4. Feeding and Nutrition

Feeds mainly on fishes, but takes also cephalopods. Has been kept successfully in captivity (see Brown et al. 1966). Specimens have been successfully maintained in captivity in Japan and the United States.

2.5. Pertinent Behavioral Features

Does not seem to create problems while kept in captivity. Strong social cohesion may cause mass strandings. This species damages fish on long-lines, worldwide.

FIG. 13. Pygmy killer whale, *Feresa attenuata*, observed in Pohai Bay, Oahu, Hawaii. The shape and large size of the dorsal fin is distinctive, as is the extent of the dark spinal field, when observed (b). This species was known for 100 yr from only two skulls until the 1950s. Subsequently schools were captured or observed in the wild. (Photographs by E. Shallenbarger.)

a
b
c

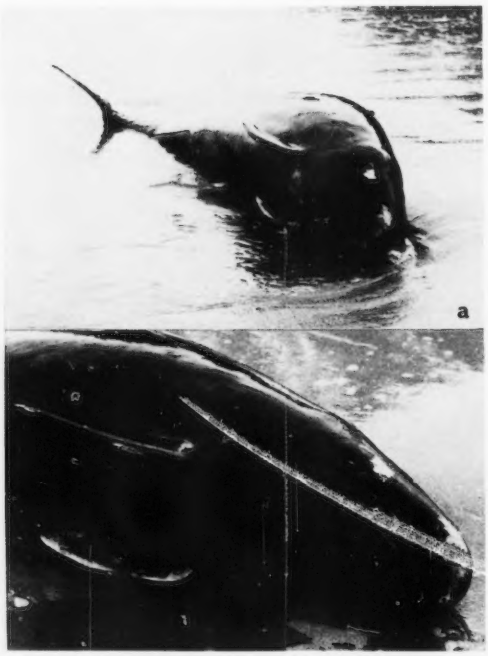

FIG. 14. False killer whale, *Pseudorca crassidens*, a nongravid female about 14 ft (4.3 m) in length, that stranded on January 14, 1970 at Ft. Pierce, Fla. This is presumably one of the animals of a January 11 mass stranding, that had been towed off shore and subsequently washed back. The species is noted for stranding *en masse*, with between 100–300 coming ashore in exceptionally large strandings. (Photographs by J. G. Mead.)

2.6. Past and Present Exploitation

Not hunted except for the few live specimens for oceanaria. According to M. Nishiwaki (unpublished data) about 30–50 specimens are taken accidentally in the Pacific each year, in tuna long line fisheries. Occasionally taken in coastal small-type whaling in Japan (see Ohsumi 1972).

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

Mass strandings may significantly affect the level of local populations.

Orcinus orca

Killer Whale

2.1. Systematics of Species

One species is recognized.

2.2. Number and Distribution of Stocks

Worldwide distribution, with greatest abundance within 500 miles (800 km) off shore in the cold waters of both hemispheres to the polar ice caps. Nothing known about separation of stocks.

2.3. Life History Parameters

Little is known about the reproductive cycle. The birth season has not been clearly defined. One calf is born after a gestation period of probably at least 12 mo. Sexual maturity off Norway is reported when females are about 16 ft (4.9 m) in length. Mature males of 22 ft (6.7 m) are noted. No data are available on the age of sexual maturity or the reproduction rate.

Calves are born at about 8 ft (2.4 m). Females attain a length of at least 23 ft (7.0 m) and males 27 ft (8.2 m), with maximum lengths possibly up to 27 ft (8.2 m) and 31 ft (9.4 m), respectively. Sexual dimorphism exists. The dorsal fin in adult males measures up to 6 ft (1.8 m) in height, compared to 3 ft (0.9 m) in females. Of the few specimens aged, the oldest is a female of at least 25 growth layers. (See Jonsgaard and Øynes 1952; Jonsgaard and Lyshoel 1970.)

2.4. Feeding and Nutrition

Fish, cephalopods, birds, and marine mammals are the important food (Nishiwaki and Handa 1958). Adult males in offshore coastal waters of the eastern North Pacific prefer to feed on sea lions, seals, porpoises, and smaller baleen whales, as do large individuals studied off Japan. Food consumption is an estimated 4% of the body weight, in fish per day.

2.5. Pertinent Behavioral Features

This species exhibits a high degree of group hunting cooperation, particularly in feeding on large marine mammals. Group sizes of up to 10 individuals are common although groups with over a hundred have been recorded. The species may have local

FIG. 15. Killer whale, *Orcinus orca*, off San Benitos Island, Baja California, Mexico. a, Breaching, February, 1973. (Photograph by W. Samaras, courtesy S. Leatherwood.) b, Adult male observed December 28, 1973. There is a live-capture fishery for this species in the northeast Pacific. (See Bigg and Wolman, this volume.) (Photograph by S. Leatherwood.)

seasonal movements related to food supply. Epimeletic or care giving behavior between individuals is documented.

This species is easily trained in captivity, and has been known to be symbiotic with man in the wild (see Mead 1962). It is also known to damage fisheries elsewhere (e.g. Iceland, Alaska, etc.)

2.6.–2.7. Past, Present, and Possible Future Exploitation

Killer whales are harvested in many regions but usually only in small numbers. The largest fisheries are off Norway (where about 250 were taken in 1970), and in Japan where 169 were taken in 1965 (see Ohsumi, this volume). Since 1962 a live-capture fishery to supply oceanaria has developed in British Columbia, Canada, and Washington, USA. A total of 67 were taken between 1962 and 1973. The fishery in all areas is likely to remain small (see Christensen, this volume; Bigg and Wolman, this volume; and Mitchell 1975).

2.8. Status of Stocks

No data are available although the world population may not be large. Concentrations appear to occur in the eastern and western north Pacific, the northeastern North Atlantic, and the Antarctic.

2.9. Relation of Stocks to Habitat

The species often predates commercially important fish, and pinnipeds. The taking of commercially important fish may affect local killer whale concentrations.

Globicephala melaena

Long-Finned Pilot Whale

2.1. Systematics of Species

The nominal species *G. edwardi* of the Southern Hemisphere is best interpreted as a subspecies or race of *G. melaena, G.m. edwardi.* (See Appendix B for taxonomic comments.)

2.2. Number and Distribution of Stocks

The Northern and Southern Hemisphere populations of *G. melaena* are widely separated geographically and clearly constitute separate groups. They have sometimes been accorded specific or subspecific rank, the southern form as *edwardi*, the northern form as *melaena.* Separate stocks have not been distinguished within these two populations, but eastern animals appear to reach a slightly larger asymptotic size than western. In the North Atlantic, where there have been extensive fisheries of this species, it is important that this question be answered.

The northern population of *G. melaena* ranges from Greenland, Iceland, and the Barents Sea in the north, to Cape Hatteras in the western Atlantic and northwest Africa (including the Mediterranean) in the eastern Atlantic. In the Southern Hemisphere *G. melaena* occurs mainly north of the Antarctic Convergence in the cold currents (Humbolt, Falkland, and Benguela) associated with the West Wind Drift.

2.3. Life History Parameters

Extensive work has been done by Sergeant (1962), according to whom (Sergeant 1962), two growth layers are laid down per annum in the dentine of the teeth. Female sexual maturity is then at 6 yr of age, pregnancy lasts 16 mo and lactation about 20 mo, giving one calf in 3 yr up to old age when fertility declines. In males, sexual maturity is delayed to 12 yr. In addition, male mortality is considerably higher than that of females throughout life (mean rates estimated at 0.058 and 0.045 per annum for ages 1–8). Polygyny must therefore occur. The species is dimorphic with males reaching about 6 m in length, females 5 m. The maximal sizes attained are slightly greater in northern European than in Newfoundland waters, probably indicating better conditions for growth (Sergeant and van Bree unpublished data). Births take place throughout the year, the majority in the northern summer.

2.4. Feeding and Nutrition

Sergeant (1962) found squid (*Illex illecebrosus*) the preferred food inshore in Newfoundland with Atlantic cod (*Gadus morhua)* taken when squid was not available. Mercer (1967) found Greenland turbot (*Reinhardtius hippoglossoides*) in an overwintering herd. The squid most commonly taken in north European waters is probably *Ommastrephes sagittatus*; fish observed in stomachs in north Britain included horse mackerel

FIG. 16. Long-finned pilot whales, *Globicephala melaena*, observed on a cruise of the *Polarstar*, on May 25, 1969 off Cape Breton Island, N.S. The shape of the dorsal fin identifies pilot whales, but species identification is more difficult. (E. Mitchell photo 361:10.)

(*Caranx trachurus*) and flatfish (Pleuronectidae).

2.5. Pertinent Behavioral Features

The behavior of schools of *G. melaena* makes it possible to drive the whole group ashore, as practiced in many of the fisheries for this species. Other species of small cetaceans school with pilot whales, and they may be driven ashore with them.

2.6. Past and Present Exploitation

There is a long history of exploitation of this species in the Northern Hemisphere (see IWS, various numbers, summarized in Mitchell 1975). In the eastern Atlantic the principal exploitation has been driving schools in the Faeroes. This has been a stable fishery, with annual catches on the order of 1500 (see Joensen 1962). Small numbers of animals have been taken in Norway, West Greenland (see Kapel, this volume, and in Mitchell 1975, p. 20), and, to a lesser extent, in Iceland. The principal fishery in the western Atlantic has been in Newfoundland, where a drive fishery was active from 1947 to 1964, with catches reaching almost 10,000 in the peak year 1956. An important drive fishery was also active at Cape Cod from the mid-1700s to the 1920s. During the late 1800s the mean annual catch appears to have been on the order of 2–3000 animals. Knowledge of the technique of driving these animals was apparently widespread, and sporadic catches are recorded from many areas (e.g. O'Riordan, this volume). Exploitation in the Southern Hemisphere has been sporadic and very low.

2.7. Possible Future Exploitation

Catches of *G. melaena* have declined in the North Atlantic and it appears that the only active fishery is in the Faeroes. Recent catches from this fishery have been low and there is no reason to assume that they might increase in the near future. It is possible that Chile and Peru may begin exploitation of the southern population (Aguayo, this volume).

2.8. Status of Stocks

The inshore stock fished by Newfoundland apparently has been depleted (Mitchell 1973, 1975; Mercer, this volume), but should be recovering. There is no indication of depletion of any other stocks.

2.9. Relation of Stocks to Habitat

The development of widespread fisheries for squid may have an effect on the populations of this species. Spontaneous mass strandings of this species may also be important and their causes need to be investigated.

Globicephala macrorhynchus

Short-Finned Pilot Whale

2.1. Systematics of Species

The short-finned pilot whale is distributed through the tropical and low temperate waters of the world. In the Atlantic it occurs as far north as Cape Hatteras, Mauritania, and Madeira, south to about 15 °S on the African coast. The distribution in northern South America is poorly known, but it probably

FIG. 17. The short-finned pilot whale, *Globicephala macrorhynchus*, is common in schools of 100 or more along the north coast of New Guinea. They are often seen motionless in groups near Madang, as in this photograph (courtesy W. H. Dawbin).

does not extend south to São Paulo. It probably occurs in all the warm waters of the Indian Ocean and along the coast of northern Australia, but not in New Zealand. In the Pacific it probably occurs south to Peru and north to the Gulf of Alaska, Japan, and southward. (See Appendix B for taxonomic comments.)

2.2. Number and Distribution of stocks.

There are indications that there are two forms of this species in the North Pacific. One is similar to *G. macrorhynchus* from the western North Atlantic, while the other is larger and differs in the shape of the head in adult males. This question requires attention as both forms are probably fished in Japan. There is no other information relating to the separation of stocks in this species.

Little is known of the distribution of stocks in the Atlantic. In the North Pacific, where there are apparently two forms of this species, there are seasonal differences in their distribution. Along the coast of eastern Japan there are two peak catch periods (June and October) at different localities, probably representing different temporal distribution of the two forms (see Ohsumi, this volume).

2.3. Life History Parameters (for western North Atlantic)

a. female length at sexual maturity 300–320 cm, in males about 480 cm, although social maturity in males probably does not occur until above 500 cm (data for western Atlantic from J. G. Mead unpublished).

b. calving interval probably about 3 yr.

c. length at birth about 140 cm; maximum recorded length for females 400 cm, males 535 cm. Fetal lengths from a mass stranding in October indicate an extended breeding and calving season.

2.4. Feeding and Nutrition

Caldwell et al. (1971) report squid and fish from Lesser Antilles. Commonly kept successfully in captivity.

2.5. Pertinent Behavioral Features

As with *G. melaena*, strong herding behavior allows the possibility of drives and may facilitate other types of fishing.

2.6. Past and Present Exploitation

Substantial catches may have been made by early whalers, e.g. there is evidence of approximately 800 caught by a small number of ships between 1850 and 1855 (Mitchell 1975, p. 82). Caldwell et al. (1971) reported a cumulative catch of 2367 for the years 1962–70 from St. Vincent Is., Lesser Antilles (and see Caldwell and Caldwell, this volume). Current exploitation in this fishery is probably 2–300 per year. Ohsumi (this volume) furnished data from the Japanese fishery for the years 1948–72, where catches

FIG. 18. Pilot whales, *Globicephala macrorhynchus*, off San Clemente Island, Calif. in April, 1974. Note the pronounced postdorsal saddle. (Photographs 4–24 and 4–30 by S. Leatherwood.)

ranged from 890 in 1949, 61 in 1955, to 91 in 1972. Live-capture fisheries have taken some pilot whales (see Walker, this volume).

2.7. Possible Future Exploitation

The Japanese and Caribbean fisheries will probably continue at current levels.

2.8. Status of Stocks

The Caribbean fishery is probably stable, but catches are large enough that population assessment should be made. There are indications that the Japanese fishery reduced Pacific stocks in the late 40s and early 50s, but reduced catches in recent years may have allowed recovery. No population estimates available. (See Caldwell and Caldwell, this volume; and Ohsumi, this volume.)

2.9. Relation of Species to Habitat

Mass strandings may have a significant effect on local populations.

Lagenorhynchus albirostris

White-Beaked Dolphin

2.1. Systematics of Species

The distribution is North Atlantic, from West Greenland, Iceland, and the Barents Sea, southwards to Massachusetts and France (Mercer 1973). (See note 9, Appendix B.)

2.2. Number and Distribution of Stocks

Mercer (1973) has described intraspecific variation in pigmentation patterns, which may be of future application in stock identification (Mercer 1973; Jonsgaard and Nordli 1952).

2.3. Life History Parameters

Grows to about 300 cm. Probably matures at 200 cm or larger.

2.4. Feeding and Nutrition

van Bree and Nijssen (1964) summarized data on food, which was a wide variety of demersal and pelagic fish.

2.5. Pertinent Behavioral Features

Has been reported in schools up to several hundred in the eastern Atlantic but mostly in small schools in the western Atlantic (Sergeant and Fisher 1957).

2.6. Past and Present Exploitation

A small, direct exploitation in Newfoundland (Sergeant and Fisher 1957) took only a few per annum. (See Mitchell 1975 for summary.)

FIG. 19. White-beaked dolphin, *Lagenorhynchus albirostris*, off Fogo Island, northeast Newfoundland, observed July 9, 1972 on the whale tagging cruise of the *Fumi*. Characteristically large dorsal fin, and white dorsal flank and blowhole blazes, are useful field marks. (Photograph by K. C. Balcomb, EDM 1267:166.)

2.7. Possible Future Exploitation

Likely to remain important only as a by-catch.

2.8. Status of Stocks

No population estimates are available but the species appears to be fairly abundant in colder waters.

2.9. Relation of Species to Habitat

Unknown.

Lagenorhynchus acutus

Atlantic White-Sided Dolphin

2.1. Systematics of Species

Distribution is from West Greenland to Cape Cod, and from the Netherlands, northwest England, and Ireland to at least Trondheim Fjord in the eastern Atlantic (Mercer 1973; van Utrecht and Husson 1968). (See note 9, Appendix B.)

2.2. Number and Distribution of Stocks.

No information.

2.3. Life History Parameters

Gestation period is 10 mo (Guldberg and Nansen 1894). Length at birth 95 cm. Parturition probably in spring to midsummer. The age of a 150-cm specimen was estimated at 3 yr (Sergeant and Fisher 1957).

2.4. Feeding and Nutrition

Sergeant and Fisher (1957) reported squid and herring in specimens examined at Newfoundland.

2.5. Pertinent Behavioral Features

Usually seen in schools of 40–50. Commonly, mass strandings occur in the northeastern United States.

2.6. Past and Present Exploitation

May sometimes be taken in association with pilot whales in drive fisheries in Newfoundland (Sergeant and Fisher 1957), in the Cape Cod fishery (Clark 1887), and entrapped in Norwegian waters (up to 1500 at one time, Tomilin 1957).

2.7. Possible Future Exploitation

Likely to remain important only as a by-catch.

2.8. Status of stocks

No population estimates but the species appears to be abundant at least near Newfoundland and Norway.

2.9. Relation of Species to Habitat

Mass strandings may have a significant effect on local populations.

Lagenorhynchus obscurus

Dusky Dolphin

2.1. Systematics of Species

This is an inshore species and appears to

FIG. 20. Atlantic white-sided dolphin, *Lagenorhynchus acutus*, observed May 25, 1969 off Cape Breton Island, Nova Scotia on the whale research cruise of the *Polarstar*. The bipartite flank and elongate peduncle readily identify this species in the field. (E. Mitchell photo 373:20.)

have a circumpolar distribution but in temperate and cooler inshore waters off South America, South Africa, Kerguelen Island, southern Australia, and New Zealand. (See note 9, Appendix B.)

2.2. Number and Distribution of Stocks

Various geographic stocks may currently be discontinuous. In South America, *L. obscurus* and *L. australis* are mainly allopatric, with *L. obscurus* commonly occurring in more temperate waters. On the west coast the northernmost record is from Isla Mazorca, Peru, and on the east coast *L. obscurus* has been recorded north to Mar del Plata, Argentina (Brownell 1974).

2.3. Life history Parameters

Males grow at least to 211 cm in total length (Brownell 1974). The size at birth is not known.

2.4. Feeding and Nutrition

Little is known about the food habits.

2.5. Pertinent Behavioral Features

No information.

2.6. Past and Present Exploitation

Live animals have been taken for aquarium display in New Zealand and South Africa. Small numbers are taken incidental to fishing operations throughout most of its range.

2.7. Possible Future Exploitation

No information.

2.8. Status of Stocks

No information.

2.9. Relation of Species to Habitat

No information.

Lagenorhynchus cruciger

Hourglass Dolphin

2.1. Systematics of Species

Pelagic circumpolar occurrence in Southern Hemisphere both north and south of Antarctic Convergence and in the cool water currents associated with the West Wind Drift (Brownell 1974). (See note 9, Appendix B.)

2.2. Number and Distribution of Stocks

No stocks have been identified.

2.3. Life History Parameters

Little is known about this species, but a male 163 cm and a female 183 cm in total length have been reported.

2.4. Feeding and Nutrition

Nothing is known about the food habits and no specimens have been maintained in captivity.

2.5. Pertinent Behavioral Features

No information.

2.6. Past and Present Exploitation

No information.

2.7. Possible Future Exploitation

No information.

2.8. Status of Stocks

No information.

2.9. Relation of Species to Habitat

No information.

Lagenorhynchus australis

Peale's Dolphin

2.1. Systematics of Species

This species is restricted to coastal southern South America and the Falkland Islands (Schevill and Watkins 1971). The northernmost records are from Comodoro Rivadavia, Argentina (45°50′S) on the east coast (Brownell 1974), and to Valparaiso (33°S) on the west coast (Aguayo, this volume). (See note 9, Appendix B.)

2.2. Number and Distribution of Stocks

Stocks have not been identified along the coast of South America.

2.3. Life History Parameters

Almost nothing is known about its life history. The maximum size recorded is 216 cm (Kellogg 1941).

2.4. Feeding and Nutrition

One specimen collected from the Falkland Islands had octopus remains in its stomach.

2.5. Pertinent Behavioral Features

Unknown.

2.6. Past and Present Exploitation

Unknown.

2.7. Possible Future Exploitation

Unknown.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown.

Lagenorhynchus obliquidens

Pacific White-Sided Dolphin

2.1 Systematics of Species

This species is found only in the North Pacific Ocean. It occurs at least to Amchitka in the north, southward in the California current to off central Baja California, Mexico, and occasionally to the tip of Baja California. In the western Pacific it is known from Kamchatka southward into the Sea of Japan, and along the entire Pacific coast of Japan. (See note 9, Appendix B.)

2.2. Number and Distribution of Stocks

A nominal species in the western North Pacific may represent a separate stock (Sleptsov (1955) 1971; Mitchell 1975).

2.3. Life History Parameters

Males and females are sexually mature at 170–180 cm and 175–186 cm respectively. The largest male and female were 201 and 226 cm, respectively. The calving season is during the summer. (Harrison et al. 1972.)

2.4. Feeding and Nutrition

Hake (*Merluccius productus*), anchovies (*Engraulis mordax*), and squid are commonly eaten by this species (Fitch and Brownell 1968). This species has been successfully maintained in captivity in the USA for approximately 20 yr; and in recent years it has been kept in Japanese aquaria (M. Nishiwaki, personal communication). Walker (this volume) reported 50% mortality in *L. obliquidens* within the first 6 mo of capitivity, but the average captive age of 10 *L. obliquidens* surviving beyond the first year is about 5 yr; five of these have lived in captivity over 8 yr.

2.5. Pertinent Behavioral Features

In southern Californian waters, schools traveling, but not schools engaged in feeding, are easily approached for live capture (Walker, this volume). This species is difficult to catch by the drive fisheries method in Japanese waters (Nishiwaki, this volume).

2.6. Past and Present Exploitation

Catches of this species are probably low in all types of fisheries in Japanese waters (Nishiwaki, and Ohsumi, this volume). This species is commonly taken live in southern California waters for aquarium display (Walker, this volume).

2.7. Possible Future Exploitation

In Japanese waters, the exact rate of catch

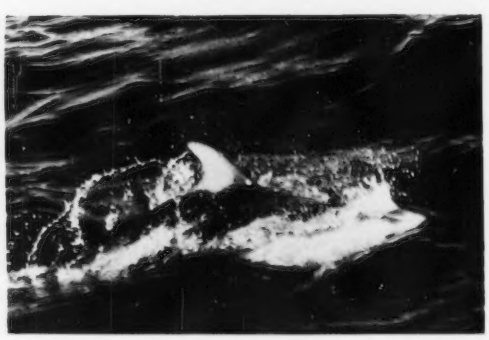

FIG. 21. Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, off southern California. This species has been maintained in captivity at a number of oceanaria. The dorsal flank blaze, thoracic patch, and fin blaze help identify the species in the wild. (Photograph by G. E. Lingle, courtesy S. Leatherwood.)

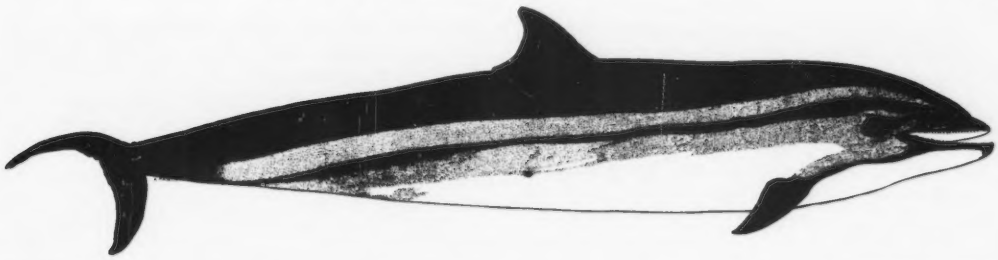

FIG. 22. Fraser's dolphin, *Lagenodelphis hosei*, unknown except for a skeleton collected before 1895 on a beach in Sarawak, until a number of sightings and captures were made in 1971 and 1972 (Perrin et al. 1973) in widely scattered parts of the world. (Drawn under the direction of W. H. Dawbin from a specimen, courtesy W. H. Dawbin.)

is unknown but will probably remain at present low levels. Live capture in southern Californian waters will probably remain at present levels or decrease, due to limitations imposed by the Marine Mammal Protection Act of 1972.

2.8. Status of Stocks

Unknown for northeast Pacific; for northwest Pacific Nishiwaki (1972) estimates that the population is between 30 and 50 thousand.

2.9. Relation of Species to Habitat

In the coastal southern Californian waters, where this species is abundant, the marine habitat is heavily polluted by pesticides.

Lagenodelphis hosei

Fraser's Dolphin

2.1. Systematics of Species

Until 1970, this species was known only from a single skeleton from Sarawak. More recently, it has been reported from the eastern tropical Pacific, central Pacific, Japan, Taiwan, eastern Australia, and South Africa (Indian Ocean) (Perrin et al. 1973; Tobayama et al. 1973). It is apparently a tropical species.

2.2. Number and Distribution of Stocks

Little is known of stocks in this species, but see Indian Ocean Whale Marking Cruise Report, (IWC/SC26/37).

2.3. Life History Parameters

No estimates of life history parameters exist for this species.

2.4 Feeding and Nutrition

Stomach contents contain deep-sea fishes and squids (Tobayama et al. 1973).

2.5 Pertinent Behavioral Features

This species is extremely shy of boats in some areas, possibly accounting for its obscurity. This is not the case in the Indian Ocean, however (P. B. Best personal communication). It may be more common than thought.

2.6. Past and Present Exploitation

Fraser's dolphins are involved to a minor degree in the purse seine fishery for tuna in the eastern tropical Pacific (Perrin, this volume). A few individuals have been captured in Philippine waters for exhibit in oceanaria (W. F. Perrin unpublished data).

2.7 Possible Future Exploitation

It seems unlikely that exploitation of this species will be significant in the foreseeable future.

2.8. Status of Stocks

There is no information available on status of stocks.

2.9. Relation of Species to Habitat

No ecological problems are known.

Tursiops truncatus

Bottlenose Dolphin

2.1. Systematics of Species

Distribution is world-wide in temperate to

tropical waters. Animals are mainly coastal, but in some areas may occur far offshore. (See note 10, Appendix B.)

2.2. Number and Distribution of Stocks

There appears to be two morphological forms — large and small. The large form occurs in the eastern Atlantic in European, Mediterranean, and west African waters. The smaller form occurs from Cape of Good Hope, east Africa, Red Sea, Arabian Gulf, coastal waters of the Indian subcontinent, Indonesian waters, west coast of Australia to Perth, and east coast of Australia from Sydney to New Guinea waters north to Taiwan. The small form may also occur in the tropical Pacific to America. The large form also occurs north of Taiwan, western North America, South Australia, South America, and New Zealand. The stocks on the east coast of the United States may be the small form inshore and the large form offshore, but this is uncertain. On the southwest coast of the United States the opposite may be true. In general, the large form occupies colder waters than the small form.

2.3. Life History Parameters

Age at sexual maturity is still in question and may range from 5 to 12 yr in females and 10 to 12 yr in males. Most of this data comes from animals taken in the live capture fishery in Florida. Females from Japanese waters may mature at 6–7 yr. In Florida animals, females are sexually mature at 220–235 cm and males at 245–260 cm (Harrison et al. 1972; Sergeant et al. 1973). Length at attainment of sexual maturity is different in other populations.

The calving interval is not definitely known but appears to be 2 yr. However, some old data from the northeast U.S. fishery suggest less than 2 yr. (Townsend 1914).

Animals from Florida live about 25 yr with no difference relative to sex. Aristotle (Thomson 1962) estimated longevity at 25–30 yr. Animals from Japanese waters live 30–35 yr. Calving and mating in Florida is from February to May with some activity also in September–November. Calving in Europe is in midsummer (Harrison et al. 1972).

Length at birth is 98–126 cm. Maximum is about 3 m in the small form and up to about 4 m in the larger form.

Gestation is 12 mo and lactation 12–18 mo. A female has been estimated to give birth to about eight calves in her lifetime (McBride and Kritzler 1951; Harrison et al. 1972).

2.4. Feeding and Nutrition

Tursiops feeds mainly on inshore bottom fish (Tomilin 1957) and at least in Florida and Gulf of Mexico waters, mullet makes up a major portion of the diet (Gunter 1942).

Tursiops is the most successful of all small cetaceans kept in captivity. Daily food consumption of captives is 6–7 kg.

2.5. Pertinent Behavioral Features

Tursiops is easily caught and trained in captivity. Behavior in captivity has been studied in some detail. Migrations may be on a seasonal basis related to temperature (east North Atlantic), or possibly related to food distribution. There may be inshore–offshore movements. The picture is unclear and varies locally. There is cooperation with man in some west African fisheries. *Tursiops* may hybridize with species of *Grampus*, *Steno*, and *Sousa*.

2.6. Past and Present Exploitation

Tursiops has been taken extensively in live-

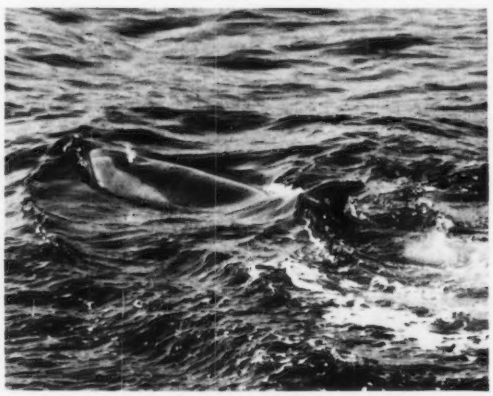

FIG. 23. Bottlenose dolphin, *Tursiops truncatus*, off Cape Cod, Massachusetts, observed on the cruise of the *Westwhale 8*, March 26, 1971. This species has been fished extensively in the Black Sea, the Atlantic coast of the United States, and elsewhere. (See Mead, and Asper, this volume.) (E. Mitchell photo 1059:183.)

capture fisheries in the U.S. (see Walker, this volume; Asper, this volume) and also in Japan and the Adriatic Sea to a lesser extent. Small fisheries exist in Japan, west Africa, Ceylon, and Indonesia. *Tursiops truncatus* was also sporadically but extensively fished in the northeast U S. over the last 100 yr. About 2000 were taken per year at the peak of the fishery (see Mead, this volume). A fishery taking several hundred existed in the Black Sea until about 1965. Small numbers are taken incidentally in the eastern tropical Pacific tuna fishery (Anon. 1973). (See Mitchell 1975 for summary of exploitation.)

2.7. Possible Future Exploitation

Live-capture fisheries for display animals may increase in other countries since inception of strict U.S. laws restricting collecting (e.g. Adriatic Sea?).

2.8. Status of Stocks

There are no estimates of population size. Some local estimates are available from past northeastern U.S. fisheries, e.g. a cumulative catch estimate of 17,000 for the stock fished off Hatteras, North Carolina in the late 19th Century (Mitchell 1975, p. 85). There has been apparent decrease in abundance in the North Sea, probably related to pollution and decreased fish stocks.

2.9. Relation of Species to Habitat

Aside from possible indirect effects of pollution in the North Sea, there is no other information. *Tursiops* may interfere with commercial and sport fishing activities. It is a true littoral species in some areas. (See Odell, this volume.)

Grampus griseus

Risso's Dolphin

2.1. Systematics of Species

The distribution of this species is worldwide in tropical to temperate seas, generally in water deeper than 100 fath (180 m). In the North Atlantic it has been reported from Newfoundland and Sweden south to the Mediterranean and the Lesser Antilles. In the South Atlantic it has been reported from Argentina (Mead, personal communication) and South Africa. In the Pacific it is found as far north as the Kuril Islands and British Columbia, and has been reported as far south as central Chile. It is probably distributed throughout the Indo-Pacific area, occurring as far south as New Zealand and Australia.

Seasonal migrations have been suggested for the Northern Atlantic, but this point is still in question.

2.2. Number and Distribution of Stocks

No information.

2.3. Life History Parameters

a. age at first reproduction — no data
b. calving interval — no data
c. others: length at birth is about 150 cm, the maximum length of males is about 400 cm, of females about 400 cm; if the anecdotal data for "Pelorus Jack" from New Zealand is correct, these animals live for at least 24 yr (Alpers 1961); males are sexually mature at lengths of 300 cm or slightly more; (see Harrison et al. 1972; Pilleri and Gihr 1969).

2.4. Feeding and Nutrition

This species feeds primarily on cephalopods. It has been maintained in captivity, and unpublished data are probably available for feeding in captivity.

2.5. Pertinent Behavioral Features

Large schools have been seen in Newfoundland, where attempts were made to drive them in the pilot whale fishery. This was not successful, as the animals became more excited than the pilot whales, and were difficult to contain. Hybridization with bottlenose dolphins may have occurred (see Fraser 1940).

2.6. Past and Present Exploitation

This species has been sporadically taken in many of the small whale fisheries (Newfoundland, Lesser Antilles, Japan, and Indonesia). (See Mitchell 1975, p. 86 for partial summary.)

2.7. Possible Future Exploitation

Occasional catches incidental to small whale fisheries will probably continue as long as these are in operation.

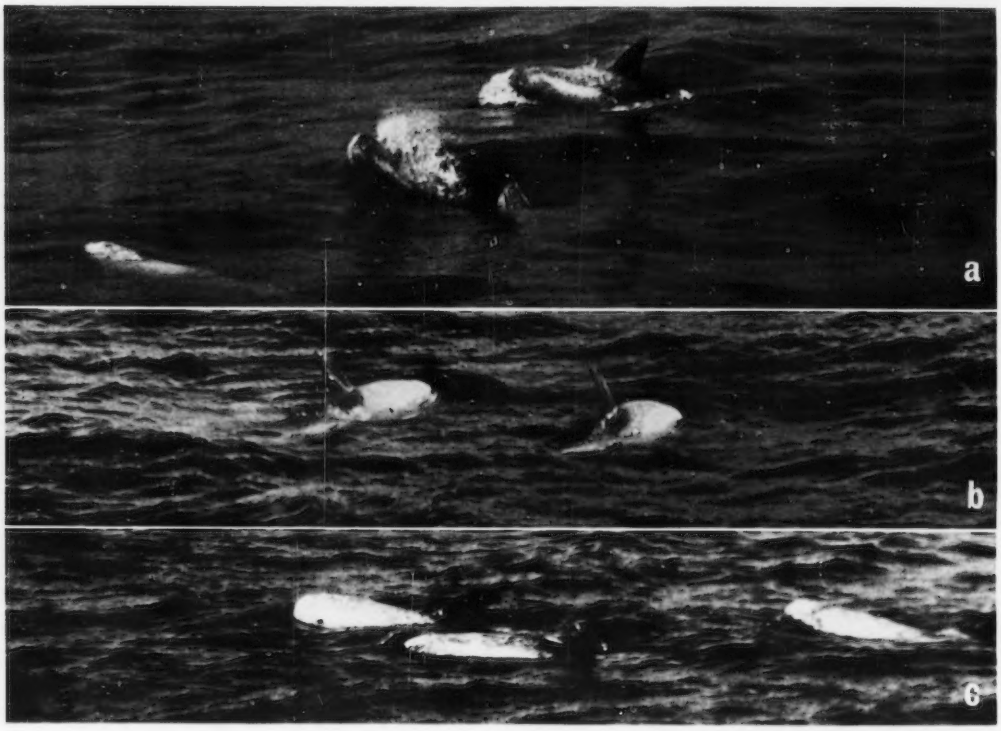

FIG. 24. Risso's dolphin, *Grampus griseus*, off the southern California coast. a, Southern California, 1973. (S. Leatherwood photograph.) b, c, Southern California. This species has been taken for live display, but does not support a major fishery anywhere. (G. E. Lingle photographs, courtesy S. Leatherwood.)

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Stenella longirostris

Spinner Dolphin

2.1. Systematics of Species

The spinner dolphin, so-called because of its habit of leaping from the water and spinning longitudinally in midair, occurs in tropical nearshore and pelagic waters of the Atlantic, Indian, and Pacific oceans. (See note 11, Appendix B.)

2.2. Number and Distribution of Stocks

At least three well-defined separate populations of spinner dolphins exist in the eastern tropical Pacific (Perrin, this volume). These are: the "Costa Rican" spinner that occurs near the coasts of Central America from El Salvador to Panama; the "Eastern" spinner that occurs near the Pacific coasts of Mexico and Guatemala, offshore about 800 km and south to about 5°N lat.; and the "Whitebelly" spinner, which occurs further offshore, to about 145° W long. and south to about 5°S lat. The range of this last form overlaps that of the eastern form in its western portion, where mixed schools and intergrades are occasionally encountered. The boundaries of the ranges fluctuate seasonally and year-to-year, in response to changing oceanographic conditions.

Less is known about subspecific variation and the nature of stocks in other waters. It should be assumed that closer inspection will reveal the existence of locally adapted forms, as in the eastern Pacific. Spinner dolphins

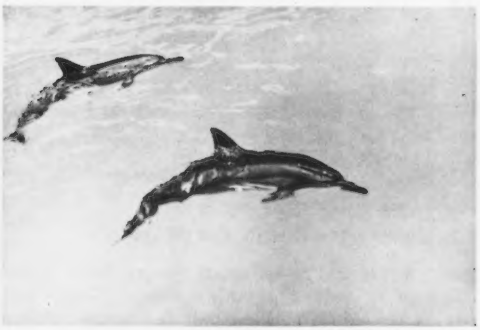

FIG. 25. Spinner dolphin, *Stenella* sp. (cf. *S. longirostris*), in Hawaiian waters. The identity and status of the race of spinner dolphin in the central Pacific needs study (Perrin, this volume). This is one of the types of dolphin involved in the porpoise–tuna fishery in the eastern tropical Pacific. (Photograph by S. Leatherwood.)

around Hawaii are disjunct and morphologically different from those to the east (Perrin 1972). The very little information available about spinner dolphins in other parts of the world indicate they are widely differentiated from one another. Spinner dolphins are known to occur in all tropical seas and have been collected from the South Pacific islands, Australia, the Solomon Islands, New Guinea, Indonesia, Japan, Ceylon, Madagascar, west Africa, the Caribbean, the U.S. east coast, and the Gulf of Mexico, among other localities in addition to the eastern tropical Pacific. Much more field work and museum work is needed to adequately define the distributions and interrelationships of these stocks.

2.3. Life History Parameters

Very little is known about growth and reproduction in the spinner dolphins. No estimates exist of calving interval or age at first reproduction, parameters of prime importance in stock assessment and management. Length at birth is approximately 80 cm, and adults of better-known forms are known to grow to 1.6–2.2 m (Anon. 1973; Perrin, this volume). Stocks in the eastern tropical Pacific differ by about 4 cm in average size of adults (Perrin, this volume). Females give birth to a single calf. Females are not known to be pregnant and lactating simultaneously (Alverson et al. 1972). It has been suggested that two seasonal reproductive peaks occur, in Spring and Fall (Harrison et al. 1969). Collection of data for estimation of parameters in the eastern Pacific has begun (Perrin, this volume and references cited therein).

Growth rates have not been estimated, although it has been suggested that spinner dolphins in the eastern tropical Pacific grow faster than do spotted Dolphins (compare *S. attenuata*) in the same area (Alverson et al. 1972). Growth layers exist in the teeth (Perrin, unpub. data), but analyses of growth have not yet been performed.

2.4. Feeding and Nutrition

Spinner dolphins feed on small, mainly mesopelagic fishes and epipelagic and mesopelagic squids (Perrin et al. 1973) in the eastern tropical Pacific. The diet is different from that of the spotted dolphin, with which it schools, in that it does not include flying fishes and other epipelagic fishes in large numbers.

It has been suggested (Fitch and Brownell 1968) that differences between food ingested by *S. attenuata* and *S. longirostris* are mainly due to the differential depth feeding habits, *longirostris* feeding "several hundred feet down", while *attenuata* feeds at or near the surface.

Spinner dolphins have been successfully maintained for several years at the Ocean Institute and Sea Life Park in Hawaii.

2.5. Pertinent Behavioral Features

Both *S. longirostris* and *S. attenuata* are closely associated with tuna schools (probably because of common food gathering), to such a degree that their presence is used by fishermen as an indication of tuna schools (Perrin 1969). The dolphins are captured in the purse seine with the tuna, and many die when they become entangled in the webbing.

The phenomenon of multispecies aggregation of dolphins and tunas is correlated with oceanographic conditions of a shallow mixed layer and thick oxygen-minimum layer. These create a well-defined, shallow, 100-m deep, pelagic habitat in the eastern tropical Pacific and other restricted regions (W. F. Perrin unpublished data).

2.6. Past and Present Exploitation

Spinner dolphins in the past have been exploited, directly or incidentally, in the purse seine fishery for tunas in the eastern tropical

Pacific (Perrin 1968; Alverson et al. 1972), in native drive fisheries in New Guinea and the Solomon Islands (Dawbin 1966), in the Japanese home islands fishery for small cetaceans (Ohsumi 1972), and in small harpoon fisheries in the Caribbean (Caldwell et al. 1971; and see Regional Accounts, below).

Latest estimates for 1970–72 of the harvest for the incidental take in the tuna fishery are (IWS 1974, 73:9):

1970	1971	1972
48,000	38,000	42,000

These estimates are for the Inter-American Tropical Tuna Commission's Yellowfin Regulatory Area only. If the tuna fishery outside the regulatory area is included, the mortality estimates may increase by 30% or more.

Current information on the status of localized indigenous fisheries are not available. Fishing for yellowfin tuna associated with spinner dolphins, which results in mortality of dolphins, continues in the eastern Pacific.

2.7. Possible Future Exploitation

Reports have been received of recent expansion of "porpoise fishing" for tuna into the eastern tropical Atlantic and near the mouth of the Red Sea. Oceanographic correlates of the tuna–dolphin association are known to exist also in the eastern tropical Atlantic (Sect. 2.5 above).

These facts indicate that future exploitation may be more extensive than past exploitation.

2.8. Status of Stocks

No estimates of population size or assessments of fishery impact exist (Anon. 1973). A U.S. Governmental report on status of stocks concluded that "population estimates and trends in abundance are not available for this species." Studies to examine status of stocks are underway by the U.S. Government (Perrin, this volume, and work in progress, e.g. docs. 24, 44).

2.9. Relation of Species to Habitat

No problems known on the basis of available data.

Stenella coeruleoalba

Striped Dolphin

2.1. Systematics of Species

The striped dolphin occurs in most tropical and temperate waters of the world's oceans (Perrin, this volume; Nishiwaki, this volume; Roux personal communication). All forms, including the nominal species *S. styx* and *S. euphrosyne* are now considered to belong to a single species (Fraser and Noble 1970; Mitchell 1970, p. 720 n). (See note 11, Appendix B.)

2.2. Number and Distribution of Stocks

Little is known about geographical variation or stocks of this species. Fraser and Noble (1970) suggested that color pattern differences between specimens from South Africa and from elsewhere may indicate existence of a local population off Durban. A possibly disjunct distributional pattern in the eastern tropical Pacific (Perrin, this volume) may indicate the presence of two stocks in that region. A complex pattern of seasonal migration of animals in Japanese waters (Nishiwaki, this volume) is consistent with the idea of a localized population in the western North Pacific. This knowledge, albeit sparse, suggests that many local stocks of the striped dolphin probably exist worldwide as they do in other species of *Stenella*.

2.3. Life History Parameters

Mean length at birth is 1 m, and length at attainment of sexual maturity is 2.2 and 2.1 m for males and females, respectively (Kasuya 1972a). Average age at sexual maturity in both males and females has been estimated at 9 yr (Kasuya 1972a) and at 5–6 yr (M. Nishiwaki unpublished data). Calving interval is estimated at about 3 yr, gestation period at 12 mo, minimum length of nursing at 18 mo (Kasuya 1972a). There are distinct seasonal peaks in reproduction (Kasuya 1972a).

2.4. Feeding and Nutrition

Striped dolphins feed heavily on small, mainly mesopelagic fishes (Miyazaki et al. 1973). Some shrimp and squid are also consumed. This species has not been maintained successfully in captivity.

2.5. Pertinent Behavioral Features

Schools of striped dolphins segregate by age and sex (Kasuya 1972a; Nishiwaki, this volume). This fact will complicate the formulation of any future management strategies. Striped dolphins in the eastern tropical Pacific

FIG. 26. Striped Dolphin, *Stenella coeruleoalba*, captured in the mid-North Atlantic on the 1967 research cruise of the *Polarstar*. This species is distributed in most temperate waters, and is fished extensively in Japan. (See article Nishiwaki, this volume.) (E. Mitchell photo 60:1 of specimen 758; see Mitchell, 1970.)

aggregate with tuna and are therefore involved in the seine fishery for tuna to a minor degree (Perrin, this volume).

2.6. Past and Present Exploitation

Up to approximately 20,000 striped dolphins have been harvested annually by the drive method and hand harpoon method in Japanese waters in recent years (Nishiwaki, this volume). It was probably fished in Japan before 1700 (Mitchell 1975, p. 26, 87). Small numbers are taken incidentally in the seine fishery for tuna in the eastern tropical Pacific (Perrin, this volume). The species is also probably taken in small numbers in various small, local, mixed-species cetacean fisheries around the world. The Japanese fishery reached an economic peak in 1952 and has since declined in catch (Nishiwaki, this volume). The Japanese drive fishery has declined in recent years because of social and economic factors (Nishiwaki, this volume).

2.7. Possible Future Exploitation

The future course of the Japanese drive fishery is problematic. Reports have been received of expansion of "porpoise fishing" for tuna to waters outside the eastern tropical Pacific, which may increase incidental exploitation of striped dolphins in tropical waters.

2.8. Status of Stocks

Estimates exist only for the population that migrates through Japanese waters. Nishiwaki (this volume), on the basis of change in the composition of the catch of 20,000, estimated population size at possibly 400,000 or more and suggested that the fishery may have had no significant impact on the population. Status of other stocks has not been examined.

2.9. Relation of Species to Habitat

Striped dolphins occur in the Mediterranean Sea, where pollution–related skin disease has been reported on a fin whale (*Balaenoptera physalus*; Viale et al. 1973) and in dolphins (Roux unpublished data).

Stenella spp.

Spotted Dolphins

2.1. Systematics of Species

Scientific names currently used for spotted dolphins include *S. attenuata* (Gray 1846) in the Pacific, Indian, and Atlantic oceans, and *S. dubia* (G. Cuvier 1812), *S. frontalis* (G. Cuvier 1829), and *S. plagiodon* (Cope 1866) in the Atlantic only. There are probably only two species. Spotted dolphins are found in nearly all coastal and offshore tropical waters of the world and in some warm temperate waters in the North and South Atlantic. (See Appendix B for expanded taxonomic comments.)

2.2. Number and Distribution of Stocks

Morphologically distinct coastal and offshore stocks of spotted dolphins exist in the eastern tropical Pacific (Perrin, this volume). Similar locally adapted forms can be assumed to exist in other less well-known regions. Small collections of specimens available from Hawaii, the South Pacific, Japan, southeast Asia, Ceylon, the Seychelles, South Africa, St. Helena in the South Atlantic, west Africa,

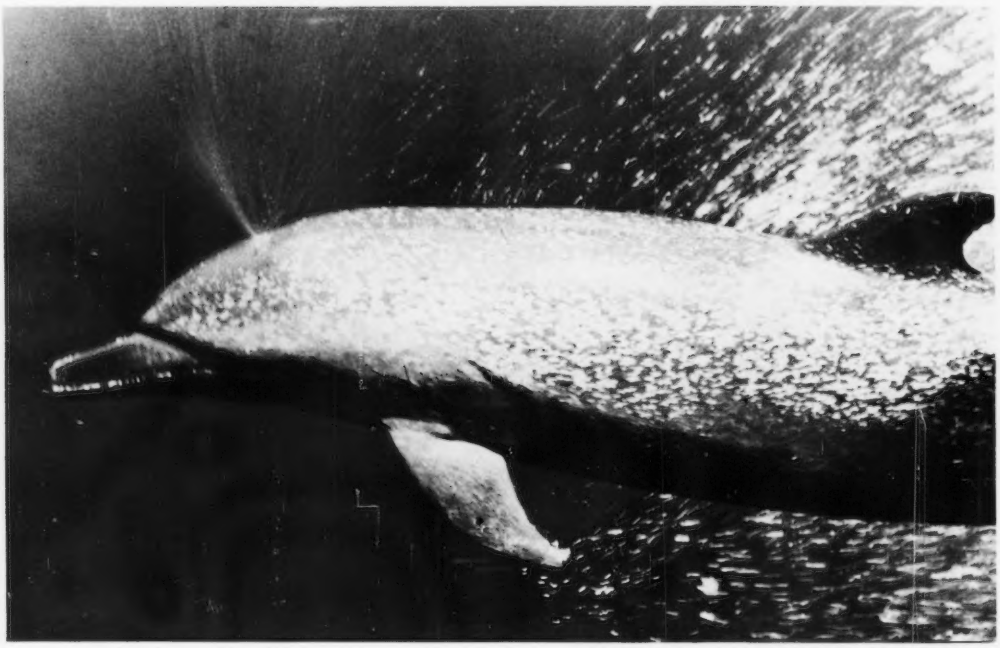

FIG. 27. Spotted dolphin, *Stenella attenuata*, riding the bow of the research vessel *David Star Jordan*, February 1974 in the eastern tropical Pacific. This is one of the species heavily involved in the porpoise–tuna fishery. (See article by Perrin in this volume.) (Photograph by K. Sexton, courtesy W. F. Perrin.)

the southeast U.S., the Caribbean, and the Gulf of Mexico support this assumption in that they vary widely in coloration, shape, size, and skeleton (Perrin 1972).

2.3. Life History Parameters

Length at birth is about 80 cm in the eastern tropical Pacific offshore stock (Anon. 1973). Adult females of this form average 187 cm, males 201 cm (Perrin, this volume). Adult females of the coastal form in the eastern tropical Pacific average 209 cm and males 228 cm (Perrin, this volume). Maximum recorded length for the coastal form is about 250 cm (Perrin, this volume). Adults of an Atlantic form (cf. *S. plagiodon*) reach 2.0–2.2 m (Anon. 1973). Age at first reproduction in the eastern tropical Pacific has been preliminarily estimated at 6–8 yr (Alverson et al. 1972). No estimates of calving interval are available. Gestation has been estimated at 10–11 mo. Overlap of reproductive cycles has been reported (Alverson et al. 1972). Average natural mortality rates (based on possible life span of 15–20 yr) are probably relatively low, approximately 0.15–0.20 (Alverson et al. 1972). No estimates of life history parameters exist for the species of spotted dolphin that is probably restricted to the Atlantic (called *Stenella plagiodon* by most workers).

2.4. Feeding and Nutrition

Spotted dolphins that associate with tuna in the eastern tropical Pacific feed on much the same prey as do the tuna, i.e. mainly epipelagic fishes such as flying fishes and epipelagic and mesopelagic squids, but do not feed on the crustaceans that form a significant portion of the stomach contents of the tuna (Perrin et al. 1973). The diet suggests that it is primarily a surface or near-surface feeder as opposed to the deeper feeding spinner dolphin. Spotted dolphins (of both species) have been successfully maintained in captivity at oceanaria in Hawaii and Florida.

2.5. Pertinent Behavioral Features

(See account for spinner dolphin, *S. longirostris*.)

FIG. 28. Atlantic spotted dolphin, *Stenella plagiodon*, captured off Cape Hatteras, North Carolina on September 15, 1966. This species of spotted dolphin is not presently known to associate closely with tuna in the northwest Atlantic, as does the spotter of the eastern tropical Pacific. (E. Mitchell photo 12:4 of specimen 695; see Mitchell 1970.)

2.6. Past and Present Exploitation

Spotted dolphins have been exploited in the same areas and by the same methods as spinner dolphins (see account for *S. longirostris*). Estimates of numbers killed in the seine fishery for tuna in the eastern tropical Pacific (IATTC Yellowfin Regulatory Area only; add 30% for entire fishery) (IWS 1974, 73:9):

1970	1971	1972
160,000	124,000	178,000

The tuna fishery continues in 1974. Little information is available on the current status of smaller local fisheries for spotted dolphins, most of which are mixed-species fisheries (see Regional Accounts). About 500–2000 spotted dolphins are taken yearly in the drive fishery on the Izu Peninsula, Japan (Nishiwaki, this volume).

2.7. Possible Future Exploitation

The same comments apply as for the spinner dolphin, *S. longirostris* (above).

2.8. Status of Stocks

No estimates exist of population sizes or trends in abundance.

2.9. Relation of Species to Habitat

Coastal stocks may be susceptible to damage by pollutants, but no problems are currently known to exist.

Delphinus delphis

Common Dolphin

2.1. Systematics of Species

Common dolphins occur worldwide in warm temperate and tropical waters, coastal and offshore. Current opinion favors recognition of a single species. (See Appendix B for taxonomic comments.)

2.2. Number and Distribution of Stocks

At least three morphologically distinct populations exist in the northeastern Pacific (Banks and Brownell 1969; W. E. Evans unpublished data). These include northern coastal and offshore stocks, ranging primarily from central California to inside the Gulf of California. In the southern part of this range, from southern California to the eastern coast of Baja California, a more neritic form occurs, the long-snouted form called *D. bairdii* by Banks and Brownell (1969). A third form occurs in warmer waters off Central America. Southern and seaward limits of distribution of this form are not well known. Other recognized local forms exist in the Black Sea (Tomilin 1957), in the Mediterranean (Gihr and Pilleri 1969), along the Atlantic coasts of Europe and Africa

(van Bree and Purves 1972), in the Indian Ocean (van Bree 1971a, c), Japan (Nishiwaki 1965), and elsewhere. Seasonal changes in the latitudinal distribution of long- and short-snouted forms in the eastern Pacific, western Pacific, and eastern Atlantic may be related to sea-surface temperature. The number of recognized populations can be expected to increase greatly with research.

2.3. Life History Parameters

Length at birth is 75–85 cm. Males grow to 2.6 m and are on average about 14 cm longer than females. Average length is greater in the eastern North Pacific than in the Black and Mediterranean Seas (Anon. 1973). Age at first reproduction in the Black Sea population has been estimated at about 3 yr (Sleptzov 1940), but this work needs re-examination. The Russian workers estimated average calving interval at about 1.3 yr. Breeding is seasonal in the eastern North Pacific, with calving peaks in spring and fall (Anon. 1973). Gestation has been estimated at 10–11 mo (Anon. 1973).

2.4. Feeding and Nutrition

The common dolphin has been reported in various areas to feed on epipelagic and mesopelagic fishes and squids and on demersal fishes (Anon. 1973). Diet varies with stock and season.

Common dolphins have been maintained successfully in oceanaria in many parts of the world, but are not readily trainable, or as hardy as other preferred dolphins (*Tursiops*, *Lagenorhynchus*, *Sousa*, and others).

2.5. Pertinent Behavioral Features

Segregation in schools by age and sex has been reported in the eastern Pacific (Anon. 1973). This must be taken into consideration in designing management strategies. Common dolphins aggregate with tuna in the eastern tropical Pacific and eastern tropical Atlantic and are therefore involved in the seine fisheries for tuna in those areas (Alverson et al. 1972; Simmons 1968). The species is known to approach vessels and to bowride, making it easily available for capture.

2.6. Past and Present Exploitation

As many as 120,000 common dolphins were once taken annually in the Black Sea (Sleptzov 1940; Mitchell 1975 summarized some data), but the take declined precipitously in the mid 1960s to insignificant levels due to depletion of the stock (Danilevskiy and Tyutyunnikov 1968). The fishery has been stopped by government edict. Estimates of numbers of common dolphins from two stocks, killed incidentally in the tuna fishery in the eastern tropical Pacific are (IWS 1974, 73:9):

1970	1971	1972
6000	5000	8000

Estimates are not available for the eastern Atlantic tuna fishery. Small numbers are taken in numerous small local indigenous drive and harpoon fisheries around the world (see Regional Accounts, below). Some nations are still fishing this species in the Black Sea. Live capture fisheries took this species in the Pacific (see e.g. Walker, this volume).

2.7. Possible Future Exploitation

Harvesting may continue in the Black Sea by some countries. The tropical tuna fisheries are expanding in area and intensity and this may lead to increased exploitation. As an extremely common animal in many parts of the world's oceans, this species seems a likely candidate for possible future increased exploitation for human consumption.

2.8. Status of Stocks

The stock in the Black Sea was depleted in the mid 1960s (Danilevskiy and Tyutyunnikov 1968). No recent published information is available regarding present status. An estimated population of 10–15,000 exists off southern and central California and Baja California (Anon. 1973). No other estimates of population size or trends in abundance are available.

2.9. Relation of Species to Habitat

Pollution may cause skin disease in the Mediterranean (Roux unpublished data). Local coastal populations in other areas may be vulnerable to damage by pollution and habitat encroachment by man.

Lissodelphis peronii

Southern Right Whale Dolphin

2.1. Systematics of Species

This dolphin is distributed circumpolar, mainly north of the Antarctic Convergence

FIG. 29. Common dolphin *Delphinus delphis*, off Coronodo Islands, Calif. This is the "Whitebelly porpoise" caught incidentally in the porpoise–tuna fishery of the eastern tropical Pacific. (Photograph by W. E. Evans, courtesy of S. Leatherwood.)

in the West Wind Drift, and it has also been commonly reported in the Humboldt current (North to 19°S), Falkland current, off shore from South Africa and around New Zealand (Brownell 1974).

2.2. Number and Distribution of Stocks

No stocks have been identified.

2.3. Life History Parameters

Nothing is known about the biology of this species.

2.4. Feeding and Nutrition

Unknown.

2.5. Pertinent Behavioral Features

These occur in schools of up to at least 1000.

2.6. Past and Present Exploitation

Occasionally taken by fishermen in Chile (Aguayo, this volume), and sporadically by whalers in the 19th century (E. Mitchell unpublished data).

2.7. Possible Future Exploitation

No information.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown.

Lissodelphis borealis

Northern Right Whale Dolphin

2.1. Systematics of Species

This species is confined to the North Pacific Ocean; mainly found in cooler offshore waters. In the eastern Pacific it occurs southward into northern Baja Californian waters and southward in the western Pacific. It occurs north to the northern half of Honshu Island, Japan (Kasuya 1971), e.g. north to 44°N in west and north to 50°N on the east side of Pacific.

2.2. Number and Distribution of Stocks

No stocks have been identified.

2.3. Life History Parameters

Little is known about the biology of this species, but a 212-cm male was immature and a 270-cm male was sexually mature (Harrison et al. 1972).

2.4. Feeding and Nutrition

Fitch and Brownell (1968) reported squid beaks and lantern fish (Myctophidae) otoliths representing at least four species in the stomach of one specimen taken in southern Californian waters.

2.5. Pertinent Behavioral Features

This species has not been successfully maintained in captivity in the USA; one specimen lived 15 mo (Walker, this volume;

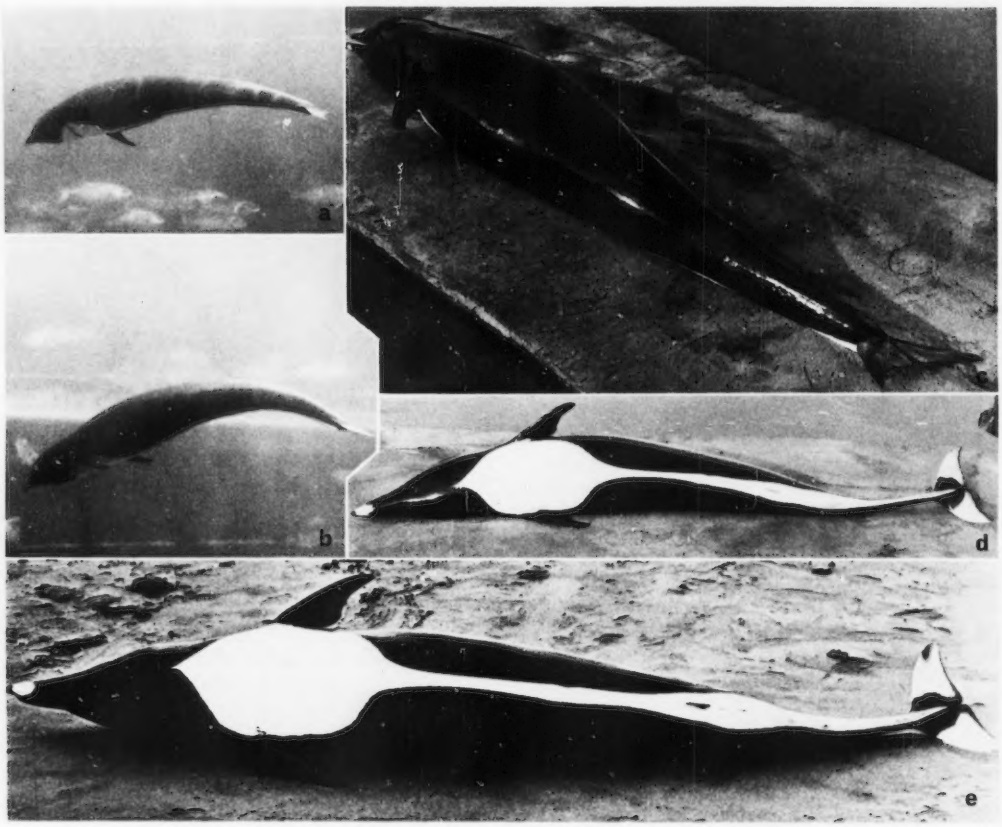

FIG. 30. Northern right whale dolphin, *Lissodelphis borealis*, captive animals in southern California. a, b, In captivity at Marineland of the Pacific, 1972. (Photographs by S. Leatherwood.) c, d, Male kept in captivity for several days at Marine Bioscience Facility at Point Mugu, Calif. (MBF 168, same animal as in Leatherwood et al. 1972, fig. 100 and see Wood, 1973, fig. on p. 34). (Photographs by F. G. Wood, courtesy S. Leatherwood.) e, Female, specimen C-156. (Photograph by J. Lewis, courtesy G. V. Morejohn and S. Leatherwood.)

and Wood 1973). None have been held in captivity in Japan (M. Nishiwaki unpublished data). Schools of over 2000 have been observed in the Pacific (Anon. 1973).

2.6. Past and Present Exploitation

Taken by whalers sporadically (R. L. Brownell unpublished data) in 19th century. In southern Californian waters, schools of this species do not readily bowride and are not easily collected (Walker, this volume), but in Japanese waters *Lissodelphis* is sometimes caught during harpoon fishery operations for billfish and tuna because the dolphins approach and move along with the vessel. *Lissodelphis* schools with mackerel in Japanese waters, and are sometimes taken (M. Nishiwaki and S. Ohsumi unpublished data). During harpoon fishery operations, *Lissodelphis* are sometimes taken if billfish and tuna are not available, mainly along the Japanese Pacific coast between Aomori to Ibaragi prefectures (Ohsumi 1972). This species is not commonly taken in the live-capture fishery in southern California waters because it is difficult to catch and maintain in captivity.

2.7. Possible Future Exploitation

None expected except for continued small catches in local Japanese fisheries.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

No information.

Cephalorhynchus heavisidii

Heaviside's Dolphin

2.1. Systematics of Species

This species is found from Cape Town to Cape Cross in the Benguela Current System (B. P. Best personal communication).

2.2. Number and Distribution of Stocks

No separate stocks have been identified.

2.3. Life History Parameters

Nothing is known about the biology of this species, but studies are in progress by P. B. Best.

2.4. Feeding and Nutrition

Same as 2.3, and to date none have been maintained in captivity. Limited data suggests that the species feeds on squid and bottom dwelling fish (P. B. Best personal communication).

2.5. Pertinent Behavioral Features

The coastal distribution of this species makes them vulnerable to coastal purse seine operations.

2.6. Past and Present Exploitation

Incidentally taken off southwest Africa in purse seine operations for commercially important fishes; annual catch probably under 100 with two other dolphin species included (see Regional Account, section 3.4; and Best in Mitchell 1975, p. 92).

2.7. Possible Future Exploitation

Rate of catches will depend on purse seine operations off southwestern Africa.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown, but oil pollution within the range of this species is increasing and may possibly affect the population levels of prey species taken.

Cephalorhynchus eutropia

Black Dolphin

2.1. Systematics of Species

This species is only found along the coast of Chile between Concepcion (37°S), south to the fjord region (55°S) near Isla Navarino (Aguayo, this volume).

2.2. Number and Distribution of Stocks

No stocks have been identified.

2.3. Life History Parameters

Nothing is known about the biology of this species.

2.4. Feeding and Nutrition

Unknown.

2.5. Pertinent Behavioral Features

A very timid coastal species.

2.6. Past and Present Exploitation

Occasionally taken by fishermen in southern Chile (Aguayo, this volume).

2.7. Possible Future Exploitation

Might continue at present level.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

No data available.

Cephalorhynchus hectori

Hector's Dolphin

2.1. Systematics of Species

Oliver (1946) described a new subspecies

C. hectori bicolor. Van Bree (1972) pointed out that Oliver's description was invalid, and that there were no valid subspecific differences in the pattern and color between *bicolor* and the variable *hectori* form. This dolphin is found only in the coastal waters around New Zealand.

2.2. Number and Distribution of Stocks

No stocks have been identified.

2.3. Life History Parameters

Nothing is known about the biology of this species. Largest recorded sizes were published by Bruyns and Baker 1973.

2.4. Feeding and Nutrition

Otoliths from engraulids were recovered from the stomach of one specimen (Walker and Brownell unpublished data). This species has been kept in captivity for a few months in Napier Marineland (Abel et al. 1971).

2.5. Pertinent Behavioral Features

No information.

FIG. 31. Hector's dolphin, *Cephalorhynchus hectori*, showing distinctive coloration and bluntly curved dorsal fin in this small species. It occurs close to shore, even entering highly turbid outflows from rivers in flood, discharging to sea. In small groups of 3–10 or more it is relatively common along the east coast of New Zealand, especially along the South Island. (Photograph courtesy W. H. Dawbin.)

2.6. Past and Present Exploitation

This dolphin is occasionally taken in trawl fishing operations in coastal New Zealand waters.

2.7. Possible Future Exploitation

Numbers caught will depend on fishing effort noted in coastal New Zealand waters.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown.

Cephalorhynchus commersonii

Commerson's Dolphin

2.1. Systematics of Species

Found in the coastal waters of the western South Atlantic Ocean along the coast of Argentina from Peninsula Valdes (approximately 42°S) southward to southern Tierra del Fuego, and Strait of Magellan; also found around the Falkland Islands, South Georgia, and Kerguelen Island (Brownell 1974).

2.2. Number and Distribution of Stocks

Stocks have not been identified, but separate stocks may occur around the offshore islands.

2.3. Life History Parameters

Nothing is known except that these dolphins reach a length of at least 137 cm.

2.4. Feeding and Nutrition

Harmer (1922) reported krill and squid pens from one specimen. To date none have been held in captivity.

2.5. Pertinent Behavioral Features

Mainly occurs coastally in small groups.

2.6. Past and Present Exploitation

Small numbers of this species (no statistics available) are taken in southern Argentina in gillnets used for crab fishing (documents no. 39 and 42), mainly during the austral summer

(December–January). Mead (in Mitchell 1975, p. 91) estimated 100 porpoises of this and other species might be taken in Argentina. It is not known if this species is taken in southern Chile by crab fishermen.

2.7. Possible Future Exploitation

Future exploitation of this species will depend on the catch effort in the crab fishery.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown.

Phocoena phocoena

Harbour Porpoise

2.1. Systematics of Species

The species is distributed from West Greenland north of Davis Strait, Baffin Island, Iceland, and the White Sea, south to Senegal in the eastern Atlantic and Cape Hatteras in the western Atlantic. In the Pacific it occurs from Point Barrow, Alaska to San Pedro, California in the east, and from the Bering Sea to the Sea of Japan coasts of Hokkaido and Honshu in the west (Gaskin et al. 1974; Mercer 1973). There appears to be a separate Black Sea population. The nominal North Pacific species *P. vomerina* is regarded as a synonym of *P. phocoena*.

2.2. Number and Distribution of Stocks

Stocks in the Atlantic and Pacific are geographically separated. From evidence of local depletion in Europe (Wolk 1969) and similarity of arrival times inshore in widely separated areas of the western Atlantic it appears that much of the seasonal movement is inshore–offshore and that many stocks, not yet distinguished, exist (Mercer 1973). There may be a Baltic to North Sea migration. It also occurs in north Norway.

2.3. Life History Parameters

a. age at sexual maturity — unknown in terms of dentinal growth layers; Fisher and Harrison (1970) estimated sexual maturity at 3 or 4 yr, at lengths of 145 cm (females) and 133 cm (males).

b. calving interval — this is unknown, but has been estimated at over 8 mo (Møhl-Hansen 1954).

c. other parameters — Møhl-Hansen (1954) also gives the following data on Baltic porpoises: length at birth (75.0 cm), weight at birth (5–6 kg), maximum length of adult males (170 cm), of females (180 cm), and weight of adult females (90 kg), longevity is at least 13 dentinal growth layers (Gaskin et al. 1974); Nielsen (1972) showed maximum length of 165 cm at six to seven growth layers in a small sample from Lille Belt; studies on age determination, and a continuing program of studies based on materials from eastern Canada are being carried out by Gaskin and students (University of Guelph).

2.4. Feeding and Nutrition

Considerable published information was summarized recently by Gaskin et al. (1974) and Smith and Gaskin (1974). The diet is mainly of smooth, nonspiny fish, especially gadoids and clupeoids.

2.5. Pertinent Behavioral Features

Aggregations of several hundred animals have been reported (Fink 1959; Rae 1965) in the North Pacific and near Britain. In the Bay of Fundy the largest school seen comprised only nine animals (Gaskin et al. 1974). A timid species, with a generally inshore distribution.

The species is difficult to maintain in captivity, but some have been held for periods of several months in Europe (reviewed by Gaskin et al. 1974).

FIG. 32. Harbour porpoise, *Phocoena phocoena*, caught in a gillnet in Baynes Sound, Vancouver Island on February 10, 1962. Similar incidental, accidental catches of this species are common in the Northern Hemisphere, especially in the northwest Atlantic. (See article by Lear and Christensen in this volume.) (Photograph by G. C. Pike of 147-cm male; same animal described by Pike and MacAskie 1969.)

2.6. Past and Present Exploitation

Harbour porpoises were killed for meat and oil by Indians on the coast of Nova Scotia (Gilpin 1878; Leighton 1937; Fisher and Harrison 1970) and are still eaten when available on the coasts of New Brunswick and in parts of northern Maine by fishing families. They are still taken in the Baltic (Wolk 1969; Ropelewski 1957, 1966 translation) where they appear to be decreasing in numbers (see Lindroth 1962). They were taken in Denmark during the Second World War (Møhl-Hansen 1954) and much earlier (Petersen 1969), and more recently by Russian fishermen during migrations between the Black Sea and the Sea of Azov from November to April (Tomilin 1967).

The annual catch at southwest Greenland ranged in the low hundreds to 1950 and recent landings were estimated around 1000 per year. (Kapel, this volume.) The 1972 by-catch in the non-Greenlandic driftnet fishery for salmon was estimated at 1500 (Lear and Christensen, this volume). There is no available estimate for the by-catch in the Greenlandic fishery or for net fisheries at Newfoundland where porpoises are commonly taken (Sergeant and Fisher 1957; Mercer 1973). (See regional accounts, below.)

2.7. Possible Future Exploitation

By-catches in gillnet fisheries and other fixed net fisheries will continue to be an important factor in mortality of the species.

2.8. Status of Stocks

Stocks in the Baltic are decreasing (van Bree unpublished data). The Baltic population fished by Danes numbered 10–15,000 porpoises, and catches of more than a few hundred per annum affected the parent stock (Mitchell 1975, p. 92–93).

2.9. Relation of Species to Habitat

a. Significant residues of chlorinated hydrocarbon insecticides were reported in the fat of harbour porpoises from the Baltic and seas around the United Kingdom (Holden and Marsden 1967). However, much higher levels, ranging to 520 ppm of extractable fat in the blubber, have been recorded recently by Gaskin et al. (1971), from animals in and near the Bay of Fundy. High levels of polychlorinated biphenyls (PCB) were also recorded, together with up to 12 ppm of dieldrin. Mercury levels appear to be a function of size of the animal, and the methylated fraction varies considerably among tissues (Gaskin et al. 1971).

b. As a markedly coastal species during warmer months, it is likely to become more subjected to coastal industrial and other development, with attendant harrassment and pollution problems.

Phocoena sinus

Cochito

2.1. Systematics of Species

P. sinus is only found in the Gulf of California, Mexico, and is most abundant in the upper part of the Gulf.

2.2. Number and Distribution of Stocks

Because of its limited distribution, probably only one stock exists (see Norris and McFarland 1958).

2.3. Life History Parameters

Two female specimens, 139 and 150 cm, were both physically mature, with epiphyses fused to centra.

2.4. Feeding and Nutrition

Remains of Grunts (*Orthopristis reddingi*) and gulf croakers (*Bairdiella icistius*) were found in the stomach of one porpoise.

2.5. Pertinent Behavioral Features

The coastal distribution of this porpoise, where gillnet fisheries operate, presents potential management problems.

2.6. Past and Present Exploitation

Occasionally taken in small numbers by fishermen in gillnet used in shark and totuava (*Cynoscion macdonaldi*) fishery.

2.7. Possible Future Exploitation

Incidental catches will depend on net fishery operations.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown.

Phocoena spinipinnis

Burmeister's Porpoise

2.1. Systematics of Species

Found coastal along the Atlantic coast of South America, from Punta del Diablo, Uruguay (e.g. Pilleri and Gihr 1972b) southward to Patagonia coast, Argentina. On the Pacific side of South America it is known from around Valdivia, Chile (39°50'S) and in the north to Bahia de Paita, Peru (05° S) (Aguayo, this volume).

2.2. Number and Distribution of Stocks

No subspecies are recognized but there are probably two stocks located on the Atlantic and Pacific coast of South America (R. L. Brownell unpublished data).

2.3. Life History Parameters

Almost nothing is known about reproduction but a near term fetus, 440 mm in total length, was collected in late February or early March in Uruguayan waters. Few external measurements are available. One specimen measured 190 cm in total length (R. L. Brownell unpublished data).

2.4. Feeding and Nutrition

Unknown.

2.5. Pertinent Behavioral Features

Unknown but coastal distribution is a potential management problem in areas where gillnet fisheries operate.

2.6. Past and Present Exploitation

Man is known to be a heavy predator along the coast of Chile and (mainly) Peru where Aguayo (this volume) and Norris (error in Mitchell 1975, p. 92 and p. 25, "meat" should read "porpoises" instead) reported that 250,000 pounds of porpoises, mainly *P. spinipinnis*, are sold each year in Peru. These porpoises are taken in gillnets along with sciaenid fishes. In addition, shark fishermen in Uruguay take *P. spinipinnis* in their gillnets (Pilleri and Gihr 1972b).

2.7. Possible Future Exploitation

Unknown.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown.

Phocoena dioptrica

Spectacled Porpoise

2.1. Systematics of Species

The species is known only from the western South Atlantic Ocean. The northernmost record is from Balneario Lagomar 34°52'S). Uruguay. The southern-most record is from Tierra del Fuego (probably the Argentina sector), but individuals are also known from the Falkland Islands (Islas Malvinas) and South Georgia Island. No specimens are known from the center of its range, along the coast of Argentina (Brownell 1974).

2.2. Number and Distribution of Stocks

No stocks are recognized in *P. dioptrica.*

2.3. Life History Parameters

Bruch (1916) reported the total length of an adult male and an adult female as 204 cm and 186 cm, respectively. A fetus, 48.4 cm in total length was obtained on July 28, 1912.

2.4. Feeding and Nutrition

Nothing is known about the food habits. No specimens have been collected alive.

2.5. Pertinent Behavioral Features

Nothing is known of the pertinent behavioral features.

2.6. Past and Present Exploitation

Unknown.

2.7. Possible Future Exploitation

No information available.

2.8. Status of Stocks

This species is known from only 10 occurrences.

2.9. Relation of Species to Habitat

Unknown.

Phocoenoides dalli

Dall's Porpoise

2.1. Systematics of Species

Phocoenoides dalli ranges from central Baja California, around the North Pacific coast to the central region of eastern Honshu, Japan. It is also found in the southern half of the Bering Sea, southern Sea of Okhotsk, and eastern Sea of Japan. It is common in inshore cold waters, but is also recorded offshore out to about 500 miles. (See note 13, Appendix B.)

2.2. Number and Distribution of Stocks

a. The form called *truei* was recorded off the eastern coast of Japan and is occasionally seen in the southern Sea of Okhotsk.

b. Stocks between eastern and western North Pacific may differ but no data are available to confirm this.

2.3. Life History Parameters

No data are presently available on the age of this species. Based on Japanese data collected off eastern Kamchatka, length at birth is 100 cm. At sexual maturity, length in females is 170 cm and in males, 185 cm. Maximum length is 210 cm in males. Births probably occur from late July to early August. Gestation probably lasts less than 1 yr. The calving interval is not known. Nothing is known about mortality rates.

2.4. Feeding and Nutrition

Food consists mainly of squid and fish.

2.5. Pertinent Behavioral Features

The group size is usually less than five individuals although groups of up to 100 are known. The species is fast swimming. There are seasonal movements, north in the summer and south in the winter.

FIG. 33. Dall's porpoise, *Phocoenoides dalli*, observed in the northeast Pacific on August 15, 1972. Large numbers are accidentally caught incidental to the gillnet fishery for salmon in the North Pacific. (See article by Ohsumi in this volume.) (Photograph by D. Lewis, courtesy S. Leatherwood.)

2.6. Past and Present Exploitation

Substantial exploitation occurs only off the northeast coast of Japan where several thousand are taken for food with hand held harpoons during the winter (see Ohsumi, this volume). During the summer off eastern Kamchatka about 10,000 are captured incidentally by Japanese gillnet fishermen (see Ohsumi, this volume). The carcasses are not utilized. Off California several dozen have been taken over the last 10 yr for research and oceanaria (see Walker, this volume). (See Mitchell 1975, p. 97–98 for summary of exploitation.)

2.7. Possible Future Exploitation

The Japanese fishery will probably continue at its present rate of exploitation.

2.8. Status of Stocks

In the western North Pacific, the population appears to be stable. In the eastern North Pacific, the population remains essentially uncropped.

2.9. Relation of Species to Habitat

A problem exists in the western North Pacific where Japanese salmon gillnet fishermen catch about 10,000 Dall porpoise incidentally. Since the carcass is not used and damage to the nets results from entanglement, the species conflicts with local fisheries operations.

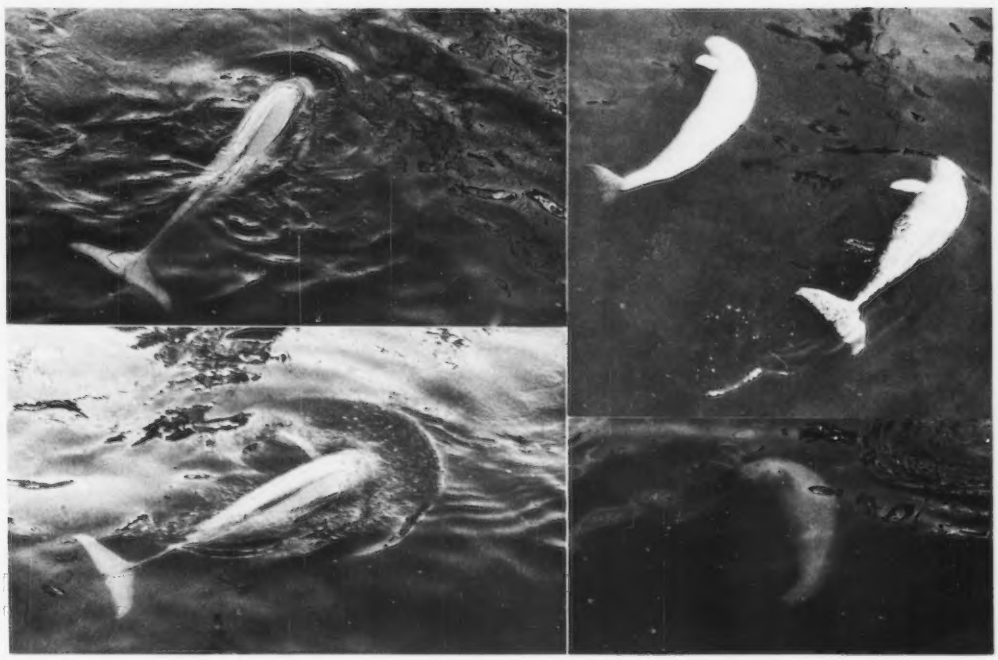

FIG. 34. Finless porpoise, *Neophocaena phocaenoides*, in captivity in Japan. This small coastal and riverine porpoise is distributed from Japan to the Arabian Sea. (Photographs by W. E. Evans, courtesy S. Leatherwood.)

Neophocaena phocaenoides

Finless Porpoise

2.1. Systematics of Species

Distribution of this coastal and riverine species is along the coast of Pakistan, India, the whole of southeast Asia, Indonesia and north to China (Tung Ting Lake), Korea and Japan, and in major rivers in that area. (See note 14, Appendix B.)

2.2. Number and Distribution of Stocks

There seems to be clinal variation in a number of morphological characteristics in the species from the Indo-Pakistan population to the Sino-Japanese population. The extreme populations have been named *N. p. phocaenoides* (Malabar Coast) and *N. p. asiaeorientalis* (Harbour of Nagasaki). Studies of intermediate populations are needed to confirm the subspecies separation. (See Pilleri and Gihr 1972a.)

2.3. Life History Parameters

Almost no data. Young appear to be born in October. Age at first reproduction not known; the same applies to other data on reproduction. Total length of full grown specimens up to 160 cm (max. 184 cm). The males are probably somewhat larger than the females.

2.4. Feeding and Nutrition

Seems to feed on small squid, small sepias, and shrimps; it also takes small sandlance and other fishes. From the Japanese population it is known that eggs on seaweed are taken and that thereby leaves are ingested. This porpoise has been successfully maintained in captivity in Japan up to 10 yr (Nishiwaki, personal communication).

2.5. Pertinent Behavioral Features

In Japan groups consist of 50 individuals subdivided in pods of 5–10 animals. These

schools migrate along the coast, close to the shore (2–3 miles offshore). It seems that groups of finless porpoises surround a school of sandlance, so that the fish cannot escape.

2.6. Past and Present Exploitation

Accidentally taken in set nets along the coast of Japan. Along the Indo-Pakistani coast, taken in shore seine nets (e.g. Dawson 1960). Exact data are not available. A few specimens have been taken during spring migration, in Ise Bay, Japan, for oceanaria. The species is protected around a small island in the Seto inland Sea of Japan. Hunted with guns and harpoons in China (Shou Chen-Huang, quoted in Mitchell 1975, p. 99).

2.7. Possible Future Exploitation

No data. Perhaps for live capture.

2.8. Status of Stocks

According to Nishiwaki (1965), the Japanese population is about 2000.

2.9. Relation of Species to Habitat

A few years ago the Ise Bay was very polluted; and the animals did not frequent that bay, but now that the bay is less polluted, the animals have returned (Nishiwaki, unpublished).

Platanista gangetica

Ganges Susu

2.1. Systematics of Species

The species is found throughout most of the Ganges and Brahmaputra river systems. (See note 15, Appendix B.)

2.2. Number and Distribution of Stocks

No stocks of this species have been identified.

2.3. Life History Parameters

Harrison (1972b) examined a number of Gangetic Susu and determined that males of 180–185 cm were not sexually mature but showed some testicular activity. Females of 200, 203, and 206 cm were sexually mature with two to six corpora in their ovaries. Kasuya (1972b) concluded that sexual maturity in females is attained at a length of 170–200 cm and in males at 170 cm, which corresponds to 10 dentinal growth layers.

Harrison (1972b) speculated that neonatal length is 70–75 cm.

There is no new information on gestation period (Harrison 1972a), and the best available information is that given by Anderson (1878, p. 422), an estimate of 8–9 mo.

Physical maturity is given by Kasuya (1972b) as: 200–210 cm for males, 250 cm for females; lengths in both correspond to an age of 20 dentinal growth layers.

2.4. Feeding and Nutrition

Various species of fish and shrimp are probably eaten by this species. A few of these dolphins have been maintained in captivity in Japan (and see Herald 1969).

2.5. Pertinent Behavioral Features

In the Ganges River, it occurs with commercially important fishes, and the fishermen set their nets around dolphins.

2.6. Past and Present Exploitation

Small numbers of these dolphins are taken incidentally by fishermen with seine nets in the Ganges River, at least around Patna. Attempts are made to release the dolphins live.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

No data.

Platanista indi

Indus Susu

2.1. Systematics of Species

There is some doubt about the specific status of this form, as some specialists consider it a subspecies of *Platanista gangetica.* Distribution is limited to the Indus River. (See note 15, Appendix B.)

2.2. Number and Distribution of Stocks

Due to the construction of barrages in the Indus, the original population has been divided into subpopulations, which have little contact with each other.

2.3. Life History Parameters

Two males of lengths of 117 and 123 cm were sexually immature. Five females between 107 and 126 cm were also sexually immature (Harrison 1972b; and Herald et al. 1969). Other data will be forthcoming, as there are still a few specimens in captivity.

2.4. Feeding and Nutrition

Animals in captivity eat 1000–1400 g of fish each day (Pilleri 1972a, b). What kind of fishes they eat in natural surroundings is not known, but might be the same as in *P. gangetica*. Specimens have been kept in captivity successfully (Institute of Brain Anatomy, Waldau-Bern; and the Steinhart Aquarium, San Francisco).

2.5. Pertinent Behavioral Features

A number of observations of the behavior of the species were published by Pilleri (1972a, b, in expedition reports). For additional reports we refer to Pilleri's papers; Kasuya (1972b) and Kasuya and Haque (1972).

2.6. Past and Present Exploitation

They are caught by the fishermen with hoopnets. The meat is eaten, the blubber is extracted for oil. According to Pilleri (1972a), there is an alarming decrease in numbers. A few specimens have been captured for live study.

2.7. Possible Future Exploitation

No data.

2.8. Status of Stocks

No data.

2.9. Relation of Species to Habitat

Few data. The impact of subdivision of the Indus River by barrages needs to be assessed (see references in Mitchell 1975, p. 99–100).

Inia geoffrensis

Boutu

2.1. Systematics of Species

While only one species is currently recognized in this genus, there are several well-separated populations. The Orinoco and Amazon populations could be considered separate subspecies, while the population from Bolivia may prove to be a separate species. *Inia* is found in all the main rivers in the Orinoco and Amazon basins. (See note 16, Appendix B.)

2.2. Number and Distribution of Stocks

Separation of stocks is based on geographic and morphologic evidence.

2.3. Life History Parameters

The length of three newborn specimens was 76–80 cm. In the Upper Amazon, males become sexually active at a length of about 228 cm, and females at 175–180 cm; parturition occurs from about July to September. Pregnancy can occur during lactation, but it is not certain whether this takes place immediately after parturition or a year later (Harrison and Brownell 1971).

2.4. Feeding and Nutrition

Catfish and other freshwater fishes, and occasional crustaceans, are eaten. These dolphins have been successfully maintained in captivity in the USA for a number of years, and recently a few have been held in Japan.

2.5. Pertinent Behavioral Features

These dolphins are not timid. It is known that they aid man in e.g. cooperative fishing (Lamb 1954). (See Layne and Caldwell 1964, for behavior in captivity.)

2.6. Past and Present Exploitation

Live dolphins for aquarium display have been captured in Venezuela, Columbia, Peru, and Brazil. Formerly, there was a small catch in Brazil for oil (Miranda-Ribeiro 1943).

2.7. Possible Future Exploitation

No information, but it is anticipated that the catch for oceanaria may remain small.

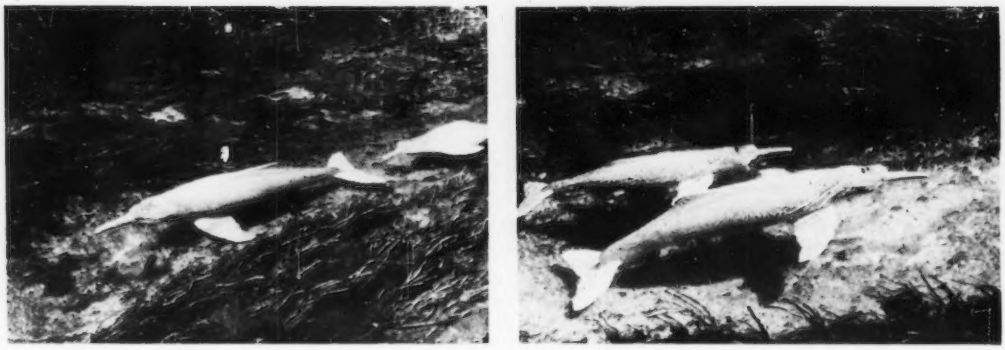

FIG. 35. Boutu, *Inia geoffrensis*, in captivity. Two specimens from the upper Amazon, in the vicinity of Leticia, Colombia were kept at Silver Springs, Fla. (Layne and Caldwell 1964). (Photographs by F. G. Wood, courtesy S. Leatherwood.)

2.8. Status of Stocks

Possibly near original level, but unknown.

2.9. Relation of Species to Habitat

Because populations are of limited distribution in rivers, and rivers are particularly susceptible to environmental disruptions, the status of these populations might be quickly and severely affected by human activity.

Lipotes vexillifer

White Flag Dolphin

2.1. Systematics of Species

Only one species, and no subspecies, are recognized. Found in Tung Ting Lake and the Yangtze River, Peoples Republic of China.

2.2. Separation and Distribution of Stocks

No stocks have been identified.

2.3. Life History Parameters

A lactating female 202 cm was captured on December 21, 1921, and a male 228.5 cm was reported to be an adult (Brownell and Herald 1972). Maximum recorded size is 250 cm. Little more is known about this species.

2.4. Feeding and Nutrition

The stomach of one specimen contained 1.9 liters of a single species of a long, eel-like catfish, and another specimen contained two large scaled fish called "Lu-yu" (Brownell and Herald 1972).

2.5. Pertinent Behavioral Features

None known.

2.6. Past and Present Exploitation

Small numbers taken accidentally during other fishing operations are used for medicinal purposes.

2.7. Possible Future Exploitation

Unknown, but Shou Chen-Huang (quoted in Mitchell 1975, p. 100) stated that "it should be well-preserved and not be fished indiscriminately."

2.8. Status of Stocks

Unknown, but this species is known only from five museum specimens (Brownell and Herald 1972; and see Hoy 1922).

2.9. Relation of Species to Habitat

Unknown.

Pontoporia blainvillei

Franciscana

2.1. Systematics of Species

A single coastal species occurs from Valdes Peninsula (42°S), Shubut, Argentina; north to Ubatuba (Tropic of Capricorn) Brazil (Ximenez et al. 1972).

2.2. Number and Distribution of Stocks

No data.

2.3. Life History Parameters

In Uruguay, the length of five near-term fetuses collected between September and December were between 63 and 70 cm. Females become sexually mature between 137 and 146 cm. The calving season is between October and January.

2.4. Feeding and Nutrition

At least 19 species of fish, three species of shrimp, and one species of squid are eaten. The midshipmen fish (*Porichthys porosissimus*) and the cutlass fish (*Trichiurus lepturus*) are the main species taken during the austral summer; and drums (Sciaenidae) are the predominant fish taken during the rest of the year. Main prey species in the austral winter are *Cynoscion striatus*, *Trachurus lathami*, and *Engraulis anchoita*. Live capture and maintenance has not been attempted to date (and see Pilleri 1971).

2.5. Pertinent Behavioral Features

No data.

2.6. Past and Present Exploitation

Exploitation mainly in Brazil, Uruguay, and Argentina, especially in Uruguay since 1942. It is caught in Brazil and Uruguay in gillnets. Approximately 500 per year are captured in Punta del Diablo, Uruguay.

2.7. Possible Future Exploitation

Unknown.

2.8. Status of Stocks

Unknown.

2.9. Relation of Species to Habitat

Unknown.

3. Regional Accounts

3.1. Arctic

Only two species are pertinent: white whale and narwhal.

White whales occur throughout the arctic and extend to the low arctic in the St. Lawrence estuary, and the Okhotsk Sea.

The status of white whales in Canada is summarized by Sergeant (this volume). Populations probably exceed 30,000. Catching has declined for economic reasons from about 1000 to 500 annually. The stock in the St. Lawrence estuary is believed to number between 500 and 1000 and to have decreased since the 1940s.

Numerical status of stocks elsewhere is not well documented. Catches in Greenland averaged about 1000 in 1969–72 (see Kapel, this volume); in Alaska were estimated at 185 in 1972 (International Whaling Statistics 1973). The former catching at Spitzbergen has ceased. There are no recent catch statistics from the Soviet Union.

In Alaska numbers at Cook Inlet are estimated at 300–500, in Bristol Bay, 1000–1500. There is no documentation for the Yukon–Kuskokwin Delta. Stocks passing the north coast in spring and autumn and enter the Mackenzie region are included in the Canadian estimate.

Narwhals are restricted to the Atlantic sector of the arctic, except for stragglers in north Alaska, and to the deep water of the arctic Atlantic. Catches in arctic Canada are about 200 annually, in Greenland about the same (International Whaling Statistics 1973, 71: 25; and Kapel, this volume). There has been apparent decline in the northeast extension of the population in Spitzbergen, and in Franz Josef Land.

3.2. Temperate North Atlantic

The principal small whale fishery in the North Atlantic is that operated by Norway (see papers by Foote, and by Christensen, this volume; Mitchell 1975, p. 19–20). Currently the most important part of the catch is the minke whale, of which about 2000 are taken per year. In recent years the catch of bottlenose whales was also important, but it

has declined recently for economic reasons. Killer whales and pilot whales have also been taken sporadically by this fishery.

A drive fishery for pilot whales has and does exist in the Faeroes for many years. Recent catches have been on the order of 1000 per year, but there are indications that this fishery is declining for social and economic reasons.

The harbour porpoise has been taken at various places along the European coast, but data are very limited (summary in Mitchell 1975, p. 92–95). Catches in the Baltic are apparently down due to a combination of environmental disturbances and possible fishing depletion. There is an unusual fishery for *Phocoena* in the Basque area of France and Spain, where the animals are taken for human consumption. Primarily the kidneys and brains are utilized; they are consumed on board the fishing vessels.

The small whale fishery in Iceland currently takes small catches of minke whales (50–100 per year), but has also taken pilot whales, killer whales, and perhaps bottlenose whales sporadically. As with many areas of the North Atlantic, *Phocoena* may be a by-catch of net fisheries in this area.

Catches of small whales in Greenland have consisted primarily of minke whales (100–200/year) and harbour porpoise (about 1000 per year). There is also a relatively large by-catch of harbour porpoise (about 1500 per year) in the salmon driftnet fishery (Lear and Christensen, this volume). Narwhals, white whales, and pilot whales have been taken sporadically in relatively low numbers (see Kapel, this volume).

The Canadian small whale fishery began primarily as a pilot whale drive fishery. This tapered off as a result of probable stock depletion (see Mercer, this volume), and was replaced by a minke whale fishery, with catches around 100 per year. Killer whales, Risso's dolphins, white-beaked and Atlantic white-sided dolphins were taken sporadically in Newfoundland, and a few bottlenose whales were taken in Nova Scotia. Small whale fishing has now ceased in Canada, though low numbers of harbour porpoise are taken incidental to net fisheries.

There formerly was an active small whale fishery in the Cape Cod area, which made substantial catches of pilot whales (2000–3000 per year) and smaller catches of perhaps 100 per year of Atlantic white-sided dolphins. There was also a major fishery for bottlenose dolphins along the North Carolina coast, where catches of about 2000 were made in peak years (see Mead, this volume; Mitchell 1975, p. 84–85); the only current fishery is the live capture fishery for bottlenose dolphins in Florida waters (see Asper, this volume). Data are not available for this fishery, but current catches will be very low due to stringent regulations. A few bottlenose dolphins and harbour porpoises may be taken incidental to other fisheries in U.S. waters.

3.2.1. Mediterranean Sea

Interest in the cetaceans of the Mediterranean is rapidly increasing, and the fauna is becoming better known (see e.g. Duguy and Cyrus 1973). Much of the knowledge, however, comes from animals sold in markets. It seems likely that most of the catch of dolphins is a by-catch from fish nets of all types, ranging from gillnets to the complex tuna traps known as madragues. Either the fishery has intensified, or increased use of synthetic fibers has put the Cetacea (as well as *Monachus*) at greater risk. Deliberate catching of *Tursiops* occurs in the Adriatic for Italian oceanaria, and it is feared that the restrictions on catching of *Tursiops* in the United States may cause this fishery to intensify. Lastly, increasing pollution has already resulted in one detected example of possible poisoning by heavy metals: that of a fin whale in the Ligurian Sea (Viale et al. 1973).

3.2.2. Black Sea

The former intensive fishing for *Delphinus* in the USSR described by Kleinenberg (1956) ceased in 1966. Dolphins are now understood to be protected in the USSR and Bulgaria, but not in Romania or Turkey. (See summary in Mitchell 1975, p. 22–23, 84, 89–90, 93–95.)

3.3. Tropical Atlantic

Purse seining for tuna associated with dolphin schools occurs in the eastern tropical Atlantic (Simmons 1968; van Bree unpublished data). The number is unknown, but catches of tuna from dolphin schools have been reported from the Gulf of Guinea and to the north off former French West Africa. Two hundred to 300 tons of small-toothed whales (about 5000 individuals) are taken

annually with tuna and landed for human consumption in the Ivory Coast and other west African nations (van Bree, letter to IUCN). Experimental purse seining "on porpoise" has been carried out by the People's Republic of the Congo. Most of the nations that seine for tuna in the eastern tropical Pacific (Sect. 3.6.1 below) also fish in the eastern tropical Atlantic, to an unknown extent for tuna associated with dolphins. It has been suggested (Caldwell and Caldwell 1971) that large schools of dolphins in the southern Caribbean are associated with tuna and that the purse seine fishery for tuna may expand to that area. It was recommended by the same authors that some uses be found for the incidentally captured dolphins in a potential fishery, so as not to waste them.

Small harpoon fisheries in the West Indies, at St. Vincent, and other localities, take large whales, pilot whales, and small numbers of dolphins for human consumption. Species taken include *Globicephala macrorhynchus*, *Orcinus orca*, beaked whales (spp. in Ziphiidae), a spotted species of cf. *Stenella frontalis*, *S. longirostris*, *Steno bredanensis*, *Tursiops truncatus*, *Grampus griseus*, *Feresa attenuata*, and *Pseudorca crassidens*. Catches include 2367 pilot whales recorded as landed at St. Vincent from 1962–70 (Caldwell et al. 1971; Caldwell and Caldwell, this volume).

Small native fisheries for small whales, dolphins, and porpoises also exist along the coast of west Africa but are not well-documented. Species known to be taken include *Delphinus delphis* (probably the most common in the fisheries), *Steno bredanensis*, *Sousa teuszii*, *Tursiops truncatus*, spotted spp. (cf. *Stenella frontalis*, *S. plagiodon*, *S. attenuata*), *Phocoena phocoena*, *Feresa attenuata*, *Grampus griseus*, *Globicephala macrorhynchus*, and *Kogia* sp. (Cadenat 1959; Brownell, unpublished data; van Bree, unpublished data).

Minke whales have been taken in the past off Brazil (Paiva 1961; Paiva and Grangeiro 1965; IWS); and catches are increasing.

The greatest potential problem in the tropical Atlantic appears to be the expanding seine fishery for tuna and the related possibility that the incidental catch of dolphins may be utilized in the future for human consumption in a larger scale than at present.

3.4. Temperate South Atlantic

The Franciscana, *Pontoporia blainvillei*, has been taken in a mixed-species gillnet fishery for sharks at Punta del Diablo, Uruguay, and three other villages near the mouth of the Rio de la Plata since at least 1942 (Brownell, this volume). Approximately 500 are taken annually at Punta del Diablo and utilized for production of oil. Additional incidental catches are made of small numbers of *P. blainvillei* (in areas other than Punta del Diablo), *Phocoena spinipinnis*, and *Tursiops* sp. in Uruguay; and *Pontoporia blainvillei*, *Lagenorhynchus obscurus*, *Phocoena spinipinnis*, *Tursiops* sp. and *Cephalorhynchus commersonii* in Argentina (Docs. M39, M42).

Reports exist of a small fishery for dolphins (mostly *Stenella* cf *S. attenuata* and *Tursiops truncatus*) in St. Helena, amounting to 20–30 animals per year. The catch method is said to be firearms and hand harpoons (Best personal communication).

Incidental catches of small numbers of *Delphinus delphis*, *Lagenorhynchus obscurus*, and *Cephalorhynchus heavisidii* occur, apparently during the purse seine operations for pilchards, anchovies, and other fishes, in waters off southwest Africa. It has been estimated that numbers caught are probably low, about 100 per year (Best personal communication).

3.5. North Pacific.

Commercial whale hunting for small cetaceans is presently conducted by Japan (see Ohsumi, this volume), Korea, China, and USSR. Whale hunting in this area by the USA ceased in 1972, and Canada stopped in 1968. Live-capture fisheries presently occur in the national waters of the USA, Canada, and Japan (see e.g. papers by Asper, by Walker, and by Bigg and Wolman, this volume).

3.5.1. Minke Whale

In the western North Pacific minke whales are taken mainly with small boats in waters around Japan, Korea, and China. A few were also taken pelagically by the large whaling boats of Japan and the USSR. The USSR has not taken coastal minke whales off the Kurile Islands since the early 1960s. No information is available on the catch by Korea, People's Republic of China, and Thailand.

3.5.2. Cuvier's Beaked Whale

In the east coast of Japan, a few Cuvier's whales are taken by small boats.

3.5.3. Baird's Beaked Whale

Small boat whaling by Japan in northeast coast of Japan and in southern Okhotsk Sea. USSR occasionally takes a small number pelagically. There is no available information regarding catches off Korea or by the People's Republic of China.

3.5.4. Pilot Whale

There is small boat whaling off eastern Japan. A drive fishery occurring in southeast Japan, including Okinawa, takes catches for food and some for oceanaria. No available data from the USSR or the People's Republic of China. A small number are captured alive for oceanaria off California.

3.5.5. Killer Whale

Small boat whaling in coastal eastern Japan and Okhotsk Sea. Occasionally taken pelagically in small numbers by USSR. No available information regarding Korea or the People's Republic of China. A small number are taken alive off the coast of Washington and British Columbia for oceanaria (Bigg and Wolman, this volume).

3.5.6. White Whale

Native people take white whales in the west and east coast of Bering Sea; however, no information on number of catch is available.

3.5.7. Dall's Porpoise

There is a small harpoon boat fishery (Ohsumi, this volume) in the northeast coast of Japan and Okhotsk Sea. They are incidentally entangled in salmon gillnets off Kamchatka. A few have been taken alive off the coast of California for oceanaria.

3.5.8. *Stenella* spp.

There is a small harpoon boat fishery in Kii Peninsula, and a drive fishery in Izu Peninsula, Japan. No fishery presently exists in the People's Republic of China or off Korea. A small harpoon fishery exists in Taiwan. They are also taken incidentally in conjunction with the tuna fishery in the eastern North Pacific.

3.5.9. Common Dolphin

Very few of these dolphins taken in the coastal fishery of Japan. Very few are taken alive in the northeastern Pacific for oceanaria.

3.5.10. Northern Right Whale Dolphin

This species is taken incidentally in purse seine nets in eastern coast of Japan. Few numbers are taken by small harpoon boats in the eastern coast of Japan. It has been taken alive in the eastern North Pacific for oceanaria.

3.5.11. Harbour Porpoise

A very small number of harbour porpoises are taken incidentally in gillnets off Kamchatka.

3.5.12. Pacific White-sided Dolphin

This animal is occasionally taken by drive fishery, and by small harpoon boats off the southwest and east central coast of Japan. A few specimens are taken alive from the drive fishery for oceanaria in Japan. There is a small live-capture fishery off the coast of California.

3.5.13. Rough-Toothed Dolphin

Occasionally it is taken alive by the drive fishery for oceanaria off the Izu Peninsula of Japan.

3.5.14. Bottlenose Dolphin

There are small numbers taken alive by drive fishery for oceanaria in Japan, and a few are taken alive from the coast of California and Mexico for the same purpose.

3.5.15 Finless Porpoise

Recently, very few taken incidentally alive for oceanaria. No commercial fishery exists.

3.5.16. Risso's Dolphin

Accidental catch. Not fished commercially.

3.5.17. False Killer Whale

Taken occasionally by drive fishery in southwest coast of Japan including Okinawa.

3.5.18. Pygmy Killer Whale

No commercial catches as far as is known.

3.6. Tropical Pacific

For faunistic and oceanographic reasons, the tropical Pacific is best considered in two subunits: (1) the eastern tropical Pacific and (2) the south, central, and western tropical Pacific.

3.6.1. Eastern Tropical Pacific

An average of over 200,000 dolphins have been killed annually in the seine fishery for tuna (International Whaling Statistics 1974, 73:9). The fishermen chase and capture schools of dolphins in order to capture tuna aggregated with them, and many of the captured dolphins die before they can be released from the net (Alverson et al. 1972). Species involved include *Stenella longirostris*, a spotted species referred to provisionally as *S. attenuata*, *S. coeruleoalba*, *Delphinus delphis*, *Tursiops truncatus*, *Lagenodelphis hosei*, *Steno bredanensis*, and *Feresa attenuata* (Alverson et al. 1972; Perrin, this volume) with the first two most important. The fishery is mostly in international waters, from Cabo san Lucas, Baja California, Mexico, south to northern Peru, and offshore to about 145° W long. Vessels of the United States, Mexico, Canada, Costa Rica, Panama, Spain, France, Japan, Bermuda, and Surinam are known to take part in the fishery, which has expanded greatly in recent years both in size and in number of nations involved. Programs of research into biology and population status of the dolphins and into improved technology for releasing dolphins from the nets have been initiated by the U.S. and Canadian governments (Alverson et al. 1972; Perrin, this volume; doc. M12, M40, M44).

Small numbers of dolphins have been captured in the past for use as shark bait on the west coast of Mexico. At present, taking of marine mammals is prohibited in Mexico.

FIG. 36. Common dolphin, *Delphinus delphis*, observed from the *Saluda*, breaching off Baja California in early December 1969. This species is the third most commonly caught in the eastern tropical Pacific porpoise–tuna fishery. (E. Mitchell photo 740:185.)

3.6.2. Central, Southern, and Western Tropical Pacific

Dolphins of several species are captured for display and research at oceanaria in Hawaii, including *Stenella longirostris*, a spotted species cf *S. attenuata*, *Tursiops truncatus*, *Pseudorca crassidens*, *Globicephala macrorhynchus*, *Steno bredanensis*, and *Feresa attenuata*. Recently species, including *Lagenodelphis hosei* and *Peponocephala electra*, have been captured in Philippine waters for display at an oceanarium in Hong Kong (S. H. Ridgway personal communication). Oceanaria in Australia have kept *Sousa chinensis*, *Stenella longirostris*, and *Tursiops truncatus* captured in tropical waters off northeastern Australia (D. Brown personal communication).

Native fishermen in the Solomon Islands and New Guinea capture entire schools of dolphins by the drive method (Dawbin 1966). Species involved include *Stenella longirostris*, a spotted species cf *S. attenuata*, *S. coeruleoalba*, *Delphinus delphis*, *Steno bredanensis*, and *Grampus griseus* (W. Dawbin personal communication). Catch statistics are not available, but indications are that annual catches have been in the thousands. Small native harpoon and drive fisheries possibly exist elsewhere in southeast Asia and tropical oceania (e.g. Mitchell 1975, p. 82).

False killer whales and possibly other cetaceans damage and reduce the catch of the Japanese longline fishery for tunas and billfishes in the tropical Pacific by removing or mutilating fish on the longline hooks. The extent of this damage has been estimated by Yamaguchi (1964). A few false killer whales become snagged on the hooks and die (Nishiwaki unpublished data).

Another conflict between small cetaceans

FIG. 37. Spotted dolphins, *Stenella* cf. *S. attenuata*, at Malaita in the southern part of the British Solomon Island Protectorate. The dolphins are located up to 10 miles from land. A dozen canoes with three men each drive them towards and then into a small harbor using stones that are struck together under water to make a sharp sound. As the canoes close in with the dolphins in shallow water near shore, the effect of the sound increases until the dolphins dive vertically into the muddy bottom where their beaks become embedded. The islanders then dive after them, take them ashore and use the meat as food and the teeth in strings of 100 as currency. (Photograph from Dawbin 1966, courtesy W. H. Dawbin.)

and fishing exists in Hawaiian waters, where local fishermen have complained that dolphins interfere with net fisheries and should be controlled (Perrin unpublished data).

In Australia, dolphins (*Stenella longirostris* and *Orcaella brevirostris*) are occasionally captured accidentally in anti-shark nets outside public beaches in northern Queensland together with large numbers of dugongs (Heinsohn personal communication). This problem may intensify throughout the tropical Pacific as tourism and recreational use of beaches increase.

Dolphins (mainly *Stenella* spp.) are extremely common in many parts of the tropical Pacific and are easily captured using modern purse seine technology. They compromise a relatively untapped resource, for human consumption. The potential for vastly increased exploitation in the near future, and the concomitant management problems, definitely exist and should be recognized.

3.7. Temperate South Pacific

Burmeister's porpoise, *Phocoena spinipinnis* is taken in a net fishery for sciaenid fishes in Peru. Up to about 125 tons of small cetaceans are sold annually in local markets (K. S. Norris, in Mitchell 1975). A few dusky dolphins, *Lagenorhynchus obscurus*, are also taken.

In Chile, fishermen occasionally take dolphins for human consumption and for use as fish bait in Arica, Iquique, Antofagasta, and Coquimbo in the north and between Concepción and Valdivia in the south. Species taken include *Phocoena spinipinnis* (the main species), *Lagenorhynchus obscurus*, *L. australis*, *Lissodelphis peroni*, and *Cephalorhynchus eutropia* (Aguayo unpublished data). The long-finned pilot whale, *Globicephala melaena*, is one of the most abundant smaller cetaceans off the Chilean coast, and it is probable that in the near future this

FIG. 38. A school of 16 killer whales, *Orcinus orca*, comprised of seven males and nine females, in the process of stranding along a gently sloping beach on the west coast, North Island, New Zealand. (Photograph courtesy W. H. Dawbin.)

animal will be utilized by the Chilean whaling industry (Aguayo, this volume).

Oceanaria in New Zealand exhibit dolphins captured in local waters, including *Delphinus delphis*, *Lagenorhynchus obscurus*, *Cephalohynchus hectori*, and *Tursiops truncatus*.

3.8. Indian Ocean

Approximately 100 minke whales are taken per year by regular catcher vessels and landed at Durban, South Africa. Five killer whales were landed in 1971, and up to July 1972, twelve killer whales were taken in the same fishery. There is some interest in bottlenose whales, but none have yet been taken from this station (P. Best personal communication June 18, 1971 and May 2, 1972). According to unconfirmed reports, many dolphins are taken by foreign tuna purse seiners operating off the coast of southeast South Africa. Approximately 60 dolphins a year (mostly *Tursiops* and *Sousa*) are taken accidentally in shark nets set off Durban (P. B. Best personal communication).

Small numbers of dolphins are hunted or taken accidentally along the east coast of central Africa, Madagascar, and adjacent islands. Larger numbers of dolphins are taken by fishermen along the borders of the Arabian Gulf and Persian Gulf, and according to unconfirmed reports, dolphins are caught together with tuna at the eastern side of the Gulf of Aden.

Fish seining operations in the Ganges River around Patna, India (approximately 300 miles northwest of Calcutta) take Susu (*Platanista gangetica*) as a by-catch to fishing. There, as well as in the Indus River system, these dolphins are taken as a by-product in a fishery for fish. Robert Brownell estimates that a few hundred are taken every year (unpublished data). The techniques used in capturing these dolphins were described by Pilleri (1970), who in more recent publications has noted a rapid decline in the stock in the Indus River (*Platanista indi*).

In Ceylon dolphins are offered for sale at the markets, and most probably the *Stenella* skulls in the British Museum (Natural History) from the Ceylon area come from fishermen (see also Medcof 1963).

Along the borders of the Bay of Bengal, dolphins are also taken in small numbers, either accidentally or in a fishery. For Indonesian waters, no active whale hunting exists except for the activities of villagers on islands between the Banda Sea and the Savu Sea (Weber 1923; and confirmed recently by van Bree unpublished data).

Along the western Australian coast, there formerly was a whaling station at Carnarvon for baleen and sperm whales, where occasionally smaller whales were also taken. This whaling station is now closed.

Whether or not small cetaceans are taken in the Indian Ocean proper in tuna, longline or shark fisheries is not known (see also Reid

1971). The offshore purse seine fisheries at the western side of the Indian Ocean have been mentioned above.

3.9. Antarctic

The small cetacean catch is almost entirely composed of minke whales (*Balaenoptera acutorostrata*). A few southern bottlenose whales (*Hyperoodon planifrons*), Arnoux's beaked whales (*Berardius arnuxii*), and killer whales (*Orcinus orca*) are also taken (International Whaling Statistics). The pygmy right whale is sometimes taken accidentally and for scientific study (e.g. Ivashin et al. 1972).

4. Types of Fisheries

4.1. Drive Fisheries

In this type of fishery the animals are maneuvered into a confining situation where they are either entrapped or immediately driven ashore and killed. Driving is usually accomplished with a number of small boats, which are used to herd the animals. In many cases special efforts are made to generate noise, which aids both in containing the school and in hastening its movements.

Whole schools are generally taken in drive fisheries. In many cases this results in the capture of animals of all sizes and sexes, but in cases where schools are segregated by age or sex, only a limited class (e.g. immature males) may be taken. Depending on the availability of the schools to the fishery, there is considerable danger of overexploitation in this type of fishing, and management policy must take the above considerations into account. The catches might be relatively low, but if they were taking only one segment of the population (such as mature females), the resulting depletion might be disproportionately large. This type of fishery might, however, allow the selective cropping of less productive portions of the population (e.g. immature males).

In general, drive fisheries are local, depending on the natural movement of schools into a limited area. In most of these the schools are driven a matter of a few kilometers. The Japanese drive fishery for dolphins is an exception to this, however, where scouting boats are employed to spot schools of dolphins, which may then be driven up to 50 or 60 km.

In the simplest types of drive fisheries, the animals are driven directly onto the shore, and the whole school is killed at once. In some fisheries (e.g. Newfoundland) animals have been driven into narrow bays, which were then closed off, confining the school and allowing animals to be killed and taken from it over a longer period of time. In Denmark, harbour porpoises (*Phocoena*) were driven directly into nets, while in the Gulf of St. Lawrence belugas (*Delphinapterus*) were herded into weirs. (See papers by O'Riordon and by Mercer, this volume.)

4.2. Net Fisheries

These are fisheries in which some type of net is used specifically for the capture of cetaceans (catches incidental to other net fisheries, and live capture are considered elsewhere). This is a relatively uncommon type of fishery for small cetaceans, though some of the drive fisheries utilizing nets might also be considered in this category. Fixed nets (traps) have been used in the beluga fishery in Spitzbergen, where they are set along the coast in areas where the belugas are moving along the shore. Here the animals are merely entrapped by the net, then dispatched by some other means. In the Cape Hatteras *Tursiops* fishery, seines were set against the shore and the animals were immediately hauled ashore with the nets. Most of the net fisheries take whole schools of animals at a time. One exception, however, is the *Platanista* fishery in the Indus River, where single animals are taken with a small net thrown from a platform set up in the river. (See papers by Mead, Ohsumi, Lear and Christensen, Perrin, and Brownell in this volume.)

4.3. Harpoon and Shoulder Gun Fisheries

In these fisheries individual animals are taken with a hand thrown harpoon, a small harpoon fired from a shoulder gun, or

FIG. 39. Long-finned pilot whales, *Globicephala melaena*, being driven ashore in Chapel Arm, Trinity Bay, Newfoundland in August of 1952. This intensive summer fishery peaked with a catch of almost 10,000 whales in 1956, but catches declined steeply thereafter. (Photos by D. E. Sergeant; other photographs in Sergeant 1953, and Mitchell 1975; see text, and Mercer, this volume, for discussion on stock collapse.)

are shot with a conventional rifle. This is possibly the commonest type of small cetacean fishery, as it requires very little equipment and is a technique commonly used for other animals as well. In most of these fisheries the animal is harpooned either with a line fixed to the boat, or more commonly, with a line fixed to a float which the animal is allowed to tow. If not killed by the harpoon, the animal is dispatched by some other means, then taken into the boat. In a few areas (e.g. the Alaskan beluga fisheries) the animals are first shot with a conventional rifle, wounding them and allowing the boat to come sufficiently close for a harpoon to be used. In this latter form of fishery there may be a significant number of animals killed but not recovered by the fishermen.

4.4. Catcher Boat Fisheries

These differ from the preceding type of fishery only in the size of the equipment used. In this type of fishery a harpoon gun is mounted on the bow and/or stern of a boat, allowing the capture of larger animals, and increasing the effective range of the harpoon. Catcher boats are nearly always used in conjunction with relatively elaborate processing facilities (shore station or factory ship). However, in some areas (such as West Greenland), where the vessels are used for other types of fishing as well, the processing may be done right on the beach. This type of fishery may be conducted pelagically with a factory ship or combination catcher–factory ship. One of the few departures from the standard fishing techniques occurs in Japan, where a harpoon gun firing multiple harpoons is used for medium-sized whales.

Catcher boat fisheries for small cetaceans are known to exist in Japan, Norway, Greenland, China, Korea, Brazil, and South Africa. Pelagic small whale fisheries exist in the North Atlantic and the Antarctic. The Canadian catcher boat fishery for small whales has recently been closed. Small whales have also been occasionally taken by catcher boats incidental to fisheries for larger whales. (See papers by Ohsumi and Foote, this volume.)

4.5. Live-Capture Fisheries

These are fisheries of generally limited scope in which animals are taken alive for display or scientific purposes. There are two principal techniques now in use, seines and hoopnets. In the former, a seine is set around the animals, in shallow water. They may then be transferred into a boat, or, in the case of larger animals, directly into a holding pen. The hoopnet is placed over the head of a single animal from the bow of a moving boat. The animal is then transferred to the boat and transported to a holding facility. This technique is used only for small animals. Various other techniques, including harpoons, tail grabs, and hand-capture methods have been used to lesser extents. Additional information on live-capture fisheries is contained in the papers of Asper, Walker, and Bigg and Wolman (this volume).

4.6. Utilization of Small Cetaceans

1. Food, human consumption — The bulk of the small whale fisheries fall into this category (see Foote, this volume). In these fisheries the meat and various viscera are processed for human consumption, the blubber is used for food and/or reduced to oil, and the remains are sometimes processed for animal food or fertilizer.

2. Food, animal consumption — In some areas, and with some species, the meat is considered unsuitable for human consumption and is used for animal food. The remains are usually processed as above.

3. Oil — In the past, many of the small cetacean fisheries were primarily for oil. At the present time, petroleum, vegetable, and synthetic oils have reduced the demand for animal oil and the oil is considered as a by-product.

4. Fertilizer — This item has long been a by-product of some fisheries.

FIG. 40. Narwhal, *Monodon monoceros*, in a net fishery for scientific specimens conducted by the Arctic Biological Station. Top, retrieving male narwhal from net; center, freeing net of ice; and bottom, recording morphometrics; all in Koluktoo Bay, Milne Inlet, northern Baffin Island in August 1965 when over 30 narwhals were taken. (See article by Mansfield et al. in this volume.) (Photographs by F. Bruemmer, courtesy A. W. Mansfield.)

5. Leather — At one time the Cape Hatteras *Tursiops* fishery was operated primarily for leather production, and leather has been produced by various of the beluga fisheries and the Black Sea *Delphinus* fishery. Demand for this product seems to have been reduced by the introduction of synthetics.

6. Utilization of live animals — Live animals are taken primarily for public display, although smaller numbers have been utilized for scientific purposes. In addition, live animals have been taken for use by the military of several countries.

5. Relationships Between Cetaceans and Other Fisheries

5.1. Incidental Capture of Cetaceans in Fisheries

Incidental takes of small cetaceans fall into two categories: (1) inadvertent, in gillnet, trawl, purse seine, set net, and longline fisheries, and (2) deliberate, in purse seines. These categories are considered separately below.

5.1.1. Inadvertent, Incidental Capture of Small Cetaceans

Small cetaceans of many species are taken inadvertently in fisheries of several nations (Table below, and Regional Accounts). Gillnets appear to be the major problem. Monofilament webbing is probably acoustically invisible to cetaceans (Perrin and Hunter 1972). Research is needed to develop gillnet webbing that will be more easily avoided by cetaceans and yet will be efficient in catching fish.

Estimated annual inadvertent, incidental takes of small cetaceans in fin-fish fisheries (not comprehensive) are:

FIG. 41. Dall's porpoise, *Phocoenoides dalli*, taken in the northeast Pacific. Large numbers of this species are presently caught in salmon gillnets in the North Pacific. (See article by Ohsumi in this volume.) (Photograph from G. C. Pike collection.)

1. Salmon drift gillnets
   a. North Pacific
      Phocoenoides dalli (to approximately 10,000)
      Phocoena phocoena (few)
      Globicephala macrorhynchus (a few)
      Berardius bairdii (few)
   b. North Atlantic
      Phocoena phocoena (> 1,500)
      Globicephala melaena (a few)

2. Shark gillnets
   a. Southeast coast of South America
      Pontoporia blainvillei (500 in one village)
      Phocoena spinipinnis (a few)
   b. Queensland, Australia
      Orcaella brevirostris (some)
      Stenella longirostris (a few)
   c. Gulf of California
      Phocoena sinus (5)
      Tursiops truncatus (50)

3. Other gillnets — Peru, Chile, and Argentina
   Phocoena spinipinnis (< 125 tons in Peru)
   Lagenorhynchus obscurus (some)
   Tursiops truncatus (a few)
   Cephalorhynchus commersonii (a few)

4. Clupeoid purse seines — southwest Africa
   Delphinus delphis (< 100)
   Lagenorhynchus obscurus (< 100)
   Cephalorhynchus heavisidii (a few)

5. Beach seines and throw nets for freshwater fishes — India and Pakistan
   Platanista indi and *P. gangetica* (a few hundred)

6. Set nets for several fish species — Japan
   Several small cetaceans (a few)

7. Midwater trawls
   a. North sea (herring)
      Phocoena phocoena (a few)
      Tursiops truncatus (a few)
   b. New Zealand
      Delphinus delphis (a few)
      Tursiops truncatus (100s)

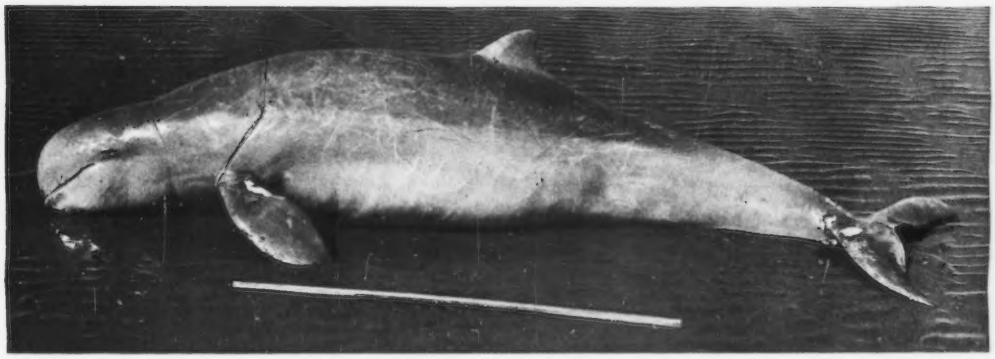

FIG. 42. Inadvertent, incidental capture of Irrawaddy dolphin, *Orcaella brevirostris*, caught and drowned in shark net set at Townsville, Queensland, Australia. Female specimen 30, June 10, 1971. (Photograph by G. E. Heinsohn.)

5.1.2. Deliberate Incidental Capture of Small Cetaceans

The taking of dolphins in tuna purse seines poses a potentially more serious problem than the inadvertent takes in other fisheries, because of the integral part that the dolphins play in the fishing operation and because of the current rapid expansion of the fisheries in intensity, geographical area, and number of nations involved.

Dolphins and tuna school together in tropical waters of the eastern Pacific, eastern Atlantic, and possibly elsewhere. Tuna fishermen take advantage of this association in two ways: (1) they find the tuna by finding dolphin schools, which are visible at the surface at a distance of several miles, and (2) they capture the tuna by herding and encircling the dolphin school. After the dolphin–tuna complex is captured in the seine, the fishermen attempt to release the dolphins, without losing the valuable tuna. Most are released, but some become entangled in the webbing and drown. The major dolphin species involved in the eastern Pacific are *Stenella attenuata*, *S. longirostris*, and *Delphinus delphis*. Small numbers of *Tursiops truncatus*, *S. coeruleoalba*, *Lagenodelphis hosei*, *Steno bredanensis*, and *Feresa attenuata* have also been reported from the fishery (Perrin, this volume). More research is needed to develop improved release techniques and to assess the impacts of these incidental kills on the dolphin populations.

5.2. Multispecies Fisheries

A multispecies fishery is herein defined as one in which two or more species of small cetaceans are taken specifically for human use and does not include small cetaceans taken incidentally in other fisheries. Multispecies fisheries are usually local and relatively small. For present purposes, they are divided into two categories: (1) animals killed and (2) animals taken alive. Fisheries in which the animals are killed for human or other consumption exist in various areas around the world including the West Indies, west Africa, St. Helena, Solomon Islands, Japan, New Guinea, Indonesia, and around the Bay of Bengal. (See Regional Accounts for lists of species taken.) Live-capture fisheries for oceanaria are found in Australia, New Zealand, Philippines, United States, Japan, and Europe. (See Regional Accounts for species taken; also Asper, Walker papers, this volume).

The possibility exists that multispecies fisheries in category (1) could unknowingly take and seriously reduce or eliminate local populations of rare species. More data on the numbers of each species taken in fisheries is desirable and can provide additional distributional and biological data.

5.3. Damage of Fisheries by Cetaceans

In several countries, small cetaceans are said to cause damages to fisheries — frightening fishes or as predators on fishes or

squid. In addition, small cetaceans are said to destroy fishing gear, but damages caused are often confused with those of other predators (i.e. sharks). It seems, however, that damages may be less now than in the past, owing to the evolution of the fisheries technology.

5.3.1. Longline and Seine Fisheries

Dolphins are caught incidentally with purse seine fisheries in coastal Japanese waters (Ohsumi, this volume). In the East China Sea where purse seine and other types of fisheries take mainly horse mackerel, *Tursiops* sp. and false killer whales are said to compete with fishermen (Nishiwaki unpublished data). Off northeastern Japan, small cetaceans compete with fishermen for squid (Nishiwaki unpublished data).

5.3.2. Gillnet Fisheries

In the North Pacific, large numbers of Dall's porpoises are incidentally killed each year by the pelagic salmon gillnet fishery (Ohsumi, this volume). The nets are damaged and the fishermen report that a great deal of time is lost removing the porpoises (Ohsumi, this volume).

5.4. Competition for Resources

Because many Odontoceti eat large fish, they have often been regarded as competitors of man. Attitudes have begun to change in the last decade, as exemplified by *Orcinus* in British Columbia which is now tolerated and even appreciated by salmon fishermen there. In Greece, however, dolphins are bountied as pests (Ronald 1973). A neutral attitude seems to exist in many of the poorer, tropical areas where the mammals themselves are utilized for oil or meat.

Increasingly the resources of the sea will be utilized by human fishermen. Yields available to natural predators will decrease. It is probable then, that the equilibrium populations of dolphin and porpoise species will decline even in the absence of direct fisheries.

6. Catch Statistics

6.1. Outline of Statistics Desired

Useful catch and effort statistics should include as a minimum:

a. species name and local vernacular name where available

b. numbers caught and gross weight of catch where available

c. numbers killed or wounded and not recovered

d. month and year of capture, and

e. some measure of effort, as for example,

(1) catcher vessel days spent hunting and capturing

(2) number of cetaceans captured and killed in each net set

(3) number of net sets per month

(4) number caught in each drive ashore and number of boats used in the drive

(5) number of hunter days expended in harpooning cetaceans

(6) modifications of these, or other suitable measures of hunting effort

In addition, wherever possible, the following biological data should be collected:

a. sex of each cetacean captured

b. body length

c. presence, length, and sex of fetus

d. lactation, and

e. stomach content

6.2. Collection of Commercial Catch Statistics

Statistics for some species of smaller whales are already gathered and compiled by the Bureau of International Whaling Statistics, Sandefjord, Norway.

In addition to collecting and compiling data from small cetacean fisheries, it is important that past data from such fisheries be brought together in such a way as to be available for use. In many cases catch and effort statistics, and to a lesser extent, biological data, have been collected for fisheries, but never published or circulated. These data can be extremely important for the demonstration of past population trends, estimation of original population sizes, etc. An attempt should be made to compile the data items listed under 6.1 for inactive fisheries and earlier phases of active fisheries, so that it will be available for analysis. Also the descriptive history of all fisheries that take small cetaceans should be researched and documented.

6.3. Documentation of Other Statistics

Data relevant to small cetaceans, but derived from sources other than catch records, should also be compiled. Into this category fall such items as kill incidental to other

fisheries, single and mass strandings, environmental disturbances, etc. As these are of a more irregular nature than the fisheries themselves, it is more difficult to outline the data to be collected. The following list will hopefully contain the more important pieces of information:

a. description of the circumstances involved
b. species involved
c. locality, date, and time
d. number of individuals
e. biological data outline in 6.1

This information should be compiled on a regional basis and published at regular intervals.

Much of the biological data necessary for population assessment (see 7.1.) can be obtained from specimens collected from past fisheries. Museum collections represent a source of data relating to such questions as age, reproduction, food habits, distribution, and stock discreteness. This is particularly true of the less well-known species, such as some of the beaked whales.

6.4. Status of Available Information

The status of available information is summarized or referred to in the text above, and in IWS, Mitchell 1975 and other published sources.

7. Biological Investigation — Methods and Techniques

7.1. Biological Items Desired for Population Assessment

7.1.1. Besides the catch statistics investigations of biological parameters are needed for population assessment, The most important biological parameters are

a. age at attainment of sexual maturity for males and females
b. natural mortality coefficients
c. calving interval
d. sex ratios
e. numbers of females served by adult males
f. age at attainment of social maturity
g. age structure of the population

7.1.2. A method of age determination is needed as a first priority item for biological studies. Studies in this field for smaller cetaceans are still undeveloped compared with large whales.

7.1.3. In the gregarious cetaceans, social structure is an important aspect of the biology for population assessment. Many kinds of toothed whales are gregarious, but information in this field is still very scarce.

7.1.4. Biological parameters change with population density. Continued investigation is needed to examine trends in change of parameters.

7.1.5. As cetaceans should be managed by stocks, stock identification studies must be developed.

7.2. Standarization and Manuals for Measurement of Small Cetaceans

Many of the external measurements have already been standardized by Norris ed. (1961). Additional measurements may be necessary to answer questions of stock and subspecific differences, but these will have to be worked out individually for each set of circumstances. Two examples of sheets for the collection of standardized data are appended (Appendix E). One, the short form, is a very brief sheet containing the minimum data necessary for identification, and meant for the use of nonspecialists. The other, the long form, is a more elaborate sheet meant for use in a large-scale, specialized operation.

An operating manual with instructions for identification and collection of data by nonspecialists is clearly needed, but beyond the scope of this meeting.

7.3. Methods and Manuals for Collecting Data on Sightings of Small Cetaceans

In order to determine the distribution and abundance of small cetaceans so that they can be properly managed, much more information is needed. Valuable information on the occurrence of marine mammals can be collected both by scientists and nonexperts. Programs to collect data are basically of two types: (1) less formal opportunistic programs, using untrained observers and (2) more formal, systematized programs using trained observers. These are considered separately below.

7.3.1. Opportunistic Programs

Untrained observers, such as fishermen, yachtsmen, crewmen on freighters, oceanographers not trained in identification of marine

mammals, navy personnel and others, can be given simple forms and identification manuals and asked to collect the following types of information for small cetaceans:

a. location
b. date
c. description, with the idea that identification should not be made if any doubt exists; description should include such things as shape of dorsal fin, shape of head, size, color, and markings as a minimum
d. number of animals, and size makeup of school
e. notes on behavior, reaction to boat, and anything else noteworthy
f. sketches, and photographs (if possible)

These data should be collected in a central place in each nation or region.

Contributions should be acknowledged in order to provide feedback and encouragement.

Two sorts of identification manuals are needed for such programs: (1) a relatively sophisticated and complete regional manual for use by more educated observers, such as government biologists, navy personnel, missionaries, educated fishermen, and (2) a very simple illustrated manual for worldwide use, with a minimal text that can be translated into several languages, for very wide distribution to laymen, uneducated fishermen, and other observers who cannot be expected to use a complicated manual.

7.3.2. Systematized Programs

Nations having or considering starting formal programs of research on the status of small cetacean populations can collect sighting data that can be used to estimate density. Such a program requires collection of data on observation effort as well as on actual sightings. Forms and techniques should be very carefully planned and standardized. Information collected for each observation period should include at least:

a. vessel name
b. observer's name
c. date
d. speed
e. beginning and ending position and time
f. estimate of maximum sighting distance
g. hours spent actually observing
h. methods used (power for binoculars, position on vessel, other activities going on, etc.)

Data for each sighting should include at least:

a. exact position
b. time
c. sea state
d. wind
e. visibility
f. sea surface temperature
g. distance of cetaceans from vessel when sighted
h. description (identification) as for 7.3.1 above
i. direction of travel of mammal(s)
j. description of school, including number, distribution, size, and sex makeup
k. description of behavior, including reaction to boat
l. sketches and photographs

Such a program should be initiated only if follow-up support is insured, so that the data can be screened, processed, and analyzed using automatic data processing methods.

7.4. Marking and Tagging

A small number of animals of some species of the smaller Cetacea have been marked with "Discovery" type whale marks in the course of marking operations mainly directed towards the larger whales. These operations were carried out by the Discovery Committee in the prewar years, and since 1945 by various authorities in different countries, and in schemes for international cooperation in whale marking (Brown, this volume).

Types of marks used in small cetaceans are:

a. 12-gauge "Discovery" type mark
b. 410 "Discovery" type mark, some with streamers
c. dart-type spaghetti mark
d. dorsal fin marks
   1) roto-tag cattle type tag
   2) roto-tag and disc
   3) roto-tag and lead acetate
   4) disc (with symbol and/or no.) for identification at sea
e. radio tag
f. freeze branding
g. marking by means of notches on dorsal fins

The "Discovery" type mark is the only one that can be at present successfully used in tagging programs for larger of the small whales. The other types require restraining the individual animals. The only exception is some instances of killer whale marking.

Brown (this volume) has given a summary of marking of small whales with "Discovery"

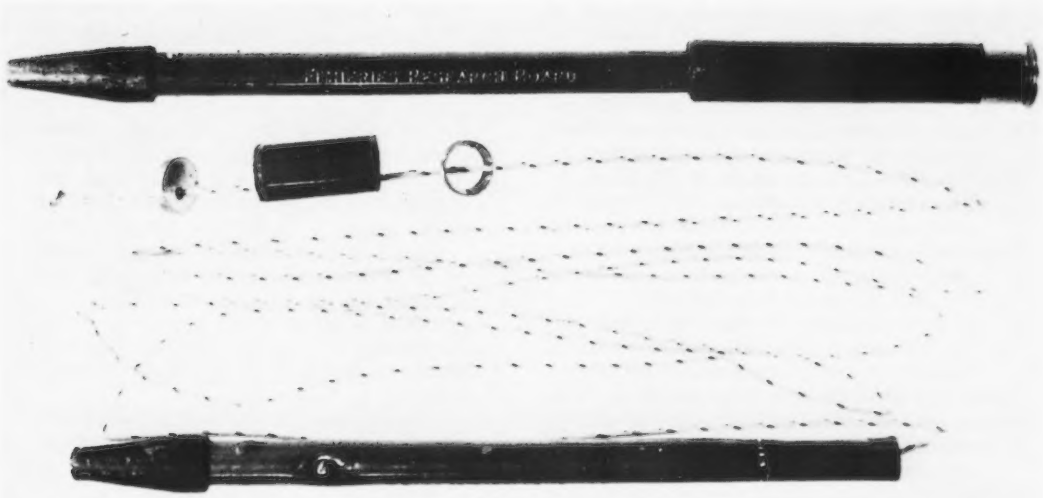

FIG. 43. Visual "Streamer" tag, prototype modified from standard .410 "Discovery" tag. (See Mitchell and Kozicki 1975.)

type marks: minke (67), killer (33), pilot (30), bottlenose (7), "beaked" whales (5), and one dusky dolphin have been marked.

Minke whale — 12-gauge and (mostly) 410 "Discovery" type marks have been used. Some of the 410 marks were streamer type. No results are available to date on performance of streamer.

To date very small numbers of animals have been tagged with consequently few recoveries. Marking has been carried out in North Atlantic, Indian Ocean, and Antarctic waters. A plan for a tagging program is being considered for the North Pacific, and the North Atlantic (in summer 1974).

As pointed out by Brown, it is emphasized here that animals less than 15 ft in length should not be tagged with "Discovery" type marks, as it is considered to be dangerous to the animal.

Dart-type spaghetti mark, cattle-type tag, disc-type tag, freeze branding, and marking by means of notches on dorsal fins all have been used on many other small cetaceans. The animals involved have to be restrained for a short period of time (minutes) in order for these types of marks to be applied. In some instances the Dart-type spaghetti mark is applied to the animal from a vessel without need of restraining the animal. A lance or a bow and arrow is used.

There are a number of species involved in this type of tagging, primarily along the Pacific Coast of North America. Species involved are:

Tursiops — small numbers
S. attenuata — 1127 (up to May 1974)
S. longirostris — 242 (up to May 1974)
Delphinus — small numbers
Lagenorhynchus — small numbers
Orcinus orca — small numbers

Tagged dolphins have been recaptured after as much as 776 days at liberty and 2400 km in net movement (Perrin, this volume).

Along the coast of Japan an experimental tagging program with the spaghetti type mark is starting on such species as Dall's porpoise and *Stenella* sp.

Disc tag, radio tag, freeze branding, and notch marks are used for individual identification by sighting and radio tracking.

Isolated instances of dolphins bearing tags have been reported, but no information is available as to who tagged the animals, indicating a need for exchanging information.

7.5. Biotelemetry

In addition to spaghetti and disc tags, radio tags have developed to advance the behavioral study of small cetaceans for the past 10 yr. In order to enlarge the range of radio propagation, radio transmitters usually are fixed on

dorsal fin of small cetaceans. Through receivers and recorders that are installed on vessel or airplane, animals can be tracked continuously at sea. When the vessel for tracking is small, the range of radio propagation is limited within 20 miles at sea, but it depends on the height of receiving antenna. The choice of radio frequency applicable for telemetry will be determined by research area. North American scientists use 27 MHz band but Japanese scientists use 169 MHz to escape interference with the communication between commercial fishing vessels.

The technology of radio telemetry provides additional direct information on diurnal behavior of unrestrained animals on the basis of individual identification, orientation, swimming speed, diving depth, diving pattern, respiration rate, ambient water temperature, and feeding activity in relation to sea bottom topography and different water masses. It is possible to track simultaneously a group of about 10 animals by improving the telemetry system. Broad frequencies allotted to biotelemetry research make it possible to track more than 10 animals at the same time. This promises rapid progress in the study of social behavior of small cetaceans in the near future.

The period of tracking depends on the life of battery contained in the transmitter, but it can be extended to some months by utilizing airplanes or a satellite as the receiving station. From such improvements the habitat preferred by population units of cetaceans can be learned. Radio tracking was carried out successfully in the Pacific for small cetaceans including *Delphinus delphis*, *Stenella attenuata*, *Tursiops truncatus*, *Orcinus orca*, and *Globicephala macrorhynchus*, etc., and gave valuable information on cetacean biology.

Ultrasonic transmitters are available in some special cases for behavioral and physiological studies; although their range of propagation underwater is shorter than radio transmitters. Telemetric study should be expedited in the future.

8. Recommendations to the Scientific Committee and Other Business

8.1. Summary

There was a consensus in the meeting that an executive summary rather than specific recommendations should be forwarded to the Scientific Committee in view of the instructions given (1.2 above). Accordingly, the chairman was asked to compile such a summary. This follows:

The first, and a major problem faced was the recognition of species of small Cetacea. A list was drawn up (Appendix B), in which 66 nominal species were recognized. An agreed-upon list of recommended common names for use in English was also developed.

Geographical subdivisions were discussed. In all well-defined species that have been critically studied, two or more distinct geographical forms or stocks have been found. Assessment and management of the small cetaceans should therefore be at the stock level.

Few data were available on initial population size, recent catches, and present population status of most species and stocks of small cetaceans.

Life history parameters were reviewed. The range of reproductive rates is from somewhat less than one calf per annum in porpoises to one calf in 2–3 yr in pilot whales and white whales, the same range as apparently found in genus *Balaenoptera*. Interpretation of the rate of deposition of growth layers in teeth is a problem of some magnitude. Longevity in odontocetes may be, in part, a function of body size. Low reproductive rates appear to be associated with long parental care and the social habit, and with relatively low juvenile mortality. Odontocetes feed mainly on fish and cephalopods, while mysticetes feed mainly on copepods, euphausiids, and small schooling fish.

Many behavioral features of small Odontocetes relate to management strategy. Schools in some species are segregated by sex and/or age. Most species are gregarious predators with highly complex social systems and a high degree of learning and accommodation.

A number of potential habitat factors may affect stocks of small cetaceans, including pesticide residues and heavy metals in the marine environment, depletion by man of food stocks, disturbance by boat and air traffic, oil pollution, and entanglement in pieces of discarded fishing nets.

Knowledge of each of the 66 species was reviewed (Systematic Overview), considering many of the above points. Status of stocks was generally unknown, but it was noted that there are large-scale direct or incidental catches of the following species at the present time:

1) Dall's porpoise, northwest Pacific
2) spotted dolphin, eastern tropical Pacific
3) spinner dolphin, eastern tropical Pacific
4) common dolphin, eastern tropical Pacific

An overview was made of regional and multispecies fisheries by geographic region, based in part on a review by Mitchell (1975). Major, commercial fisheries for small cetaceans now exist or have been carried out in the recent past — in the arctic; around the coasts of Norway, Faeroe Islands, West Greenland, Newfoundland, in the Black Sea; in the West Indies; along the coast of Uruguay; in coastal and offshore waters of Japan, Korea, China, USSR, and the USA; pelagically in the eastern tropical Pacific; along the coast of Peru and Chile; off South Africa; and pelagically in the Antarctic.

Products from small cetaceans include: food for human and animal consumption, oil, fertilizer, leather, and utilization of live animals for public display, scientific research, and work.

Types of fisheries include: drive, net, harpoon, and shoulder gun, catcher boat, and live-capture fisheries. Incidental takes of small cetaceans are: inadvertent (in gillnet, trawl, purse seine, set net, and longline fisheries), and deliberate (in purse seines).

Multispecies fisheries, in which two or more species of small cetaceans are taken, exist for the taking of animals alive, and dead. They might unknowingly take and seriously reduce or eliminate local populations of rare species.

Small cetaceans allegedly cause damage to some longline and gillnet fisheries, and are often regarded as competitors of man for fish.

The state of knowledge of small cetaceans can be much improved with the collection of statistics from fisheries. An outline of catch and effort statistics desired, and comments on the collection of other statistics and biological data is given. The use of various marks and tags is described and the relevance of biotelemetric techniques is evaluated.

8.2. Publication of Papers Submitted

There is interest in publishing the collection of papers resulting from the meeting. Pending discussion and agreement of members and observers in Montreal, the following represents one possible plan of action:

1) All participants bring single, typed copies of preliminary draft manuscripts to Montreal.

2) Papers Xeroxed in Montreal, distributed in conference, given document numbers.

3) Contributions discussed at meeting.

4) Authors modify manuscripts in light of new data, changes, and amplifications discussed at conference.

5) If arrangements, now being pursued, are successfully completed, authors submit final version of manuscript on September 1, 1974.

6) Proofs would then be available approximately February 1975.

7) And, pending arrangements, the collection of papers might be published as a supplementary number of the *Journal of the Fisheries Research Board of Canada*, appearing in first week of June 1975.

8.3. Other Business

There was no major business remaining, and the meeting was adjourned at 1800 h on Wednesday, April 10, 1974.

9. Appendices

Appendices A–E were circulated at the meeting; Appendix F was compiled by the Chairman subsequently:

9.1. Appendix A. Draft agenda
9.2. Appendix B. List of smaller cetaceans recognized
9.3. Appendix C. Subcommittee on small cetaceans – Documents
9.4. Appendix D. List of attendees
9.5. Appendix E. Cetacean data record (forms)
9.6. Appendix F. References

Appendix A

Draft Agenda

(Revised April 4, 1974)

1. Research and Information

   1.1. Introductory remarks
   1.2. Terms of reference
   1.3. Adoption of agenda

2. Review of Smaller Cetacea, Identity and Status of Species and Stocks

   2.1. Systematics of species
   2.2. Number and distribution of stocks
   2.3. Life history parameters
   2.4. Feeding and nutrition
   2.5. Pertinent behavioral features
   2.6. Past and present exploitation
   2.7. Possible future exploitation
   2.8. Status of stocks
   2.9. Relation of species to habitat

3. Regional Accounts of Fisheries

   3.1. Arctic
   3.2. North Atlantic
   3.3. Tropical Atlantic
   3.4. South Atlantic
   3.5. North Pacific
   3.6. Tropical Pacific
   3.7. South Pacific
   3.8. Indian Ocean
   3.9. Antarctic

4. Types of Fisheries for Cetaceans

   4.1. Drive fisheries
   4.2. Net fisheries
   4.3. Harpoon and shoulder-gun hunting
   4.4. Small catcher boat hunting
   4.5. Live-capture fisheries
   4.6. Use of small cetaceans

5. Relationships between Cetaceans and Other Fisheries

   5.1. Incidental capture of cetaceans in fisheries
   5.2. Multispecies fisheries
   5.3. Damages of fisheries by cetaceans
   5.4. Competition for resources

6. Catch Statistics

   6.1. Outline of statistics desired
   6.2. Collection of commercial catch statistics
   6.3. Documentation of other statistics
   6.4. Status of available information

7. Biological Investigation — Methods and Techniques

   7.1. Biological items desired for population assessment
   7.2. Standardization and manuals for measurement of small cetaceans

7.3. Cetacean sighting — field manuals and sighting grids
7.4. Marking and tagging
7.5. Biotelemetry

8. Recommendation to the Scientific Committee and Other Business

8.1. Summary and recommendation to the Scientific Committee
8.2. Publication of papers submitted
8.3. Other business

Appendix B

List of Smaller Cetaceans Recognized

The meeting had a draft manuscript (M5) listing nominal species of living Cetacea. An agreed-upon list was derived from this list, in light of taxonomic work recently published, or in progress. It was noted that, as long as the International Commission on Zoological Nomenclature has not taken a decision to the contrary, species names originally written with "*ii*" must be used. A list of recommended common names for use in English was also agreed upon. The revised list, with annotations (1) through (16), follows:

Scientific Name	Recommended Common Name
Balaenoptera acutorostrata Lacépède, 1804 (1)	Minke whale
Caperea marginata (Gray, 1846)	Pygmy right whale
Tasmacetus shepherdi Oliver, 1937	Shepherd's beaked whale
Berardius arnuxii Duvernoy, 1851 (2)	Arnoux's beaked whale
Berardius bairdii Stejneger, 1883	Baird's beaked whale
Mesoplodon pacificus (Longman, 1926) (3)	Longman's beaked whale
Mesoplodon bidens (Sowerby, 1804)	Sowerby's beaked whale
Mesoplodon densirostris (de Blainville, 1817)	Blainville's beaked whale
Mesoplodon europaeus (Gervais, 1855)	Gervais' beaked whale
Mesoplodon layardii (Gray, 1865)	Strap-toothed whale
Mesoplodon hectori (Gray, 1871)	Hector's beaked whale
Mesoplodon grayi von Haast, 1876	Gray's beaked whale
Mesoplodon stejnegeri True, 1885	Stejneger's beaked whale
Mesoplodon bowdoini Andrews, 1908	Andrews' beaked whale
Mesoplodon mirus True, 1913	True's beaked whale
Mesoplodon ginkgodens Nishiwaki and Kamiya, 1958	Ginkgo-toothed beaked whale
Mesoplodon carlhubbsi Moore, 1963	Hubbs' beaked whale
Ziphius cavirostris G. Cuvier, 1823	Cuvier's beaked whale
Hyperoodon ampullatus (Forster, 1770) (4)	Northern bottlenose whale
Hyperoodon planifrons Flower, 1882	Southern bottlenose whale
Kogia breviceps (de Blainville, 1838)	Pygmy sperm whale
Kogia simus Owen, 1866	Dwarf sperm whale
Monodon monoceros Linnaeus, 1758	Narwhal
Delphinapterus leucas (Pallas, 1776)	White whale
Steno bredanensis (Lesson, 1828)	Rough-toothed dolphin
Sotalia fluviatilis (Gervais, 1853) (5)	Tucuxi
Sousa chinensis (Osbeck, 1765) (6)	Indo-Pacific hump-backed dolphin
Sousa teuszii (Kükenthal, 1892)	*Atlantic hump-backed dolphin*
Orcaella brevirostris (Gray, 1866) (7)	Irrawaddy dolphin
Peponocephala electra (Gray, 1846)	Melon-headed whale
Feresa attenuata Gray, 1875	Pygmy killer whale
Pseudorca crassidens (Owen, 1846)	False killer whale
Orcinus orca (Linnaeus, 1758)	Killer whale
Globicephala melaena (Traill, 1809) (8)	Long-finned pilot whale
Globicephala macrorhynchus Gray, 1846	Short-finned pilot whale
Lagenorhynchus albirostris (Gray, 1846) (9)	White-beaked dolphin
Lagenorhynchus acutus (Gray, 1828)	Atlantic white-sided dolphin
Lagenorhynchus obscurus (Gray, 1828)	Dusky dolphin
Lagenorhynchus cruciger (Quoy and Gaimard, 1824)	Hourglass dolphin
Lagenorhynchus australis (Peale, 1848)	Peale's dolphin

Lagenorhynchus obliquidens Gill, 1865	Pacific white-sided dolphin
Lagenodelphis hosei Fraser, 1956	Fraser's dolphin
Tursiops truncatus (Montagu, 1821) (10)	Bottlenose dolphin
Grampus griseus (G. Cuvier, 1812)	Risso's dolphin
Stenella longirostris (Gray, 1828) (11)	Spinner dolphin
Stenella coeruleoalba (Meyen, 1833)	Striped dolphin
Stenella attenuata (Gray, 1846) *Stenella dubia* (G. Cuvier, 1812) (11) *Stenella frontalis* (G. Cuvier, 1829) *Stenella plagiodon* (Cope, 1866)	Spotted dolphins (two species)
Delphinus delphis Linnaeus, 1758 (12)	Common dolphin
Lissodelphis peronii (Lacépède, 1804)	Southern right whale dolphin
Lissodelphis borealis (Peale, 1848)	Northern right whale dolphin
Cephalorhynchus heavisidii (Gray, 1828)	Heaviside's dolphin
Cephalorhynchus eutropia (Gray, 1846)	Black dolphin
Cephalorhynchus hectori (van Beneden, 1881)	Hector's dolphin
Cephalorhynchus commersonii (Lacépède, 1804)	Commerson's dolphin
Phocoena phocoena (Linnaeus, 1758)	Harbour porpoise
Phocoena sinus Norris and McFarland, 1958	Cochito
Phocoena spinipinnis Burmeister, 1865	Burmeister's porpoise
Phocoena dioptrica Lahille, 1912	Spectacled porpoise
Phocoenoides dalli (True, 1885) (*13*)	Dall's porpoise
Neophocaena phocaenoides (G. Cuvier, 1829) (*14*)	Finless porpoise
Platanista gangetica (Roxburgh, 1801) (*15*)	Ganges susu
Platanista indi Blyth, 1859	Indus susu
Inia geoffrensis (de Blainville, 1817) (*16*)	Boutu
Lipotes vexillifer Miller, 1918	White flag dolphin
Pontoporia blainvillei (Gervais and d'Orbigny, 1844)	Franciscana

Notes

(*1*) Although further studies are necessary, *B. bonaerensis* is probably to be recognized as a synonym of *B. acutorostrata*, if the scientific names of other species of Mysticeti are applied in an equally balanced manner for both hemispheres and all stock divisions.

(*2*) The two species of *Berardius* appear to be well separated geographically, but not markedly different from one another. A detailed comparison of the two is desirable.

(*3*) The species of *Mesoplodon* are at present based upon very little material, and are consequently very poorly defined. It is best to accept the above list with the reservation that thorough studies of age, sexual and geographic variation may reduce the number of valid species.

(*4*) The two currently recognized species of *Hyperoodon* are clearly different morphologically. There are recent indications that *H. planifrons* may extend into equatorial waters in the South Pacific. There is also an unidentified ziphiid in the North Pacific which some workers feel may turn out to be a *Hyperoodon*.

(*5*) One species *Sotalia fluviatilis*, is recognized but two populations exist; one river and the other marine. Other nominal species that need study are *S. guianensis*, *S. pallida*, *S. tucuxi*, and *S. brasiliensis* (synonyms of *S. fluviatilis*).

(*6*) Two species are recognized: *S. teuszii* from west Africa and *S. chinensis* from South Africa, Indian Ocean south to Australia, and in the western Pacific from Australia north to southern China. Other nominal species, the identity of which need study, are *S. lentiginosa*, *S. plumbea*, and *S. borneensis* (synonyms of *S. chinensis*).

(*7*) Within the genus *Orcaella* only the species *brevirostris* is recognized. For the status of the form *fluminalis* we may refer to Thomas (1892) and Lloze (1973).

(*8*) van Bree (1971b) demonstrated osteologically that there are two clearly defined species of *Globicephala*, *G. melaena* and *G. macrorhynchus*. The other nominal species of this genus are best interpreted as subspecies or races of these two species. A definite problem exists in the North Pacific, where there appear to be two distinctive kinds of *G. macrorhynchus*, one which is similar to the Atlantic *G. macrorhynchus* in total length and head shape, and another (the nominal species *G. scammonii*), which is larger and has a different head shape in adult males. According to the rules of the International Commission on Zoological Nomenclature, *macrorhynchus* should be used instead of *macrorhyncha*.

(*9*) Currently six species of the genus *Lagenorhynchus* are recognized: *L. obliquidens* in the North Pacific; *L. acutus* and *L. albirostris* in the north

Atlantic, and *L. cruciger*, *L. obscurus*, *L. australis* in the Southern Hemisphere (Fraser 1966; Fraser and Noble 1968; Mitchell 1970). The taxonomic status of *L. thicolea* needs to be determined.

(*10*) Although the necessary taxonomic work has not yet been done, it seems likely that there is only one species of *Tursiops*, with sharply defined geographical races varying in body size and tooth size and distributed differentially relative to sea temperature and depth. There is great need to gather materials that will allow definitive examination of the nominal species *T. aduncus*, *T. gillii*, and *T. nuuanu*, and materials from as many other populations as possible. These names are currently used by some workers.

(*11*) The species *S. coeruleoalba* and *S. longirostris* are well defined and accepted by most experts. In addition to these two species, there are probably two more species, both spotted. One occurs in all tropical seas, the other may be restricted to the Atlantic. There is no agreement on what these should be called. The following names each may belong to either of the two species: *S. dubia* (G. Cuvier, 1812), *S. frontalis* (G. Cuvier, 1829), *S. attenuata* (Gray, 1846), *S. plagiodon* (Cope, 1866). *Stenella graffmani* has been shown (Perrin, 1972) to be a geographical race of the species occurring elsewhere in the Pacific and to which True (1906) applied the name *S. attenuata*. *S. attenuata* is being used provisionally for spotted dolphins from the eastern tropical Pacific. *S. capensis* was synonymized with *S. attenuata* by Fraser (1950). Because spotted dolphins are involved in the tuna fishery in the eastern tropical Atlantic, high priority should be given to the solution of taxonomic problems in that area.

(*12*) It appears that there is one species of *Delphinus*, with a great deal of regional variation, particularly in snout length and external coloration. The nominal species *D. capensis* is considered to be a variant of and synonymized with *D. delphis* (van Bree and Purves 1972). However, the situation with *D. tropicalis* is less clear, and it may prove to be a valid species.

(*13*) *Phocoenoides truei* probably is a form of *P. dalli*, although further study is necessary. *Phocoenoides dalli* and *P. truei* were differentiated by thoracic color pattern, but intermediate forms are now known and mixed schools are occasionally observed.

(*14*) *Neophocaena phocaenoides* is considered to contain only one species, with two geographic forms, one of which has been called *asiaeorientalis*.

(*15*) There are clearly two different populations of *Platanista*, differing both in distribution and skull morphology. There is a question, however, as to whether these should be considered separate species or merely subspecies or forms (e.g. Pilleri and Gihr 1971).

(*16*) While only one species is currently recognized in this genus, there are several well-separated populations. The Orinoco and Amazon populations could be considered separate subspecies, while *I. geoffrensis boliviensis* may prove to be a separate species.

Appendix C

SUBCOMMITTEE ON SMALL CETACEANS — DOCUMENTS

M1.	C. E. O'Riordan	Commercial whale fishing in Ireland.
M2.	C. E. O'Riordan	Pilot whales driven ashore in Ireland 1800–1973.
M3.	E. D. Asper	Mortality, selectivity, and techniques of live capture of smaller Cetacea.
M4.	D. Odell	Aspects of the life history of the bottlenosed dolphin, *Tursiops truncatus*.
M5.*	W. E. Schevill and E. Mitchell	Preliminary list of living Cetacea.
M6.	Ch. Roux	Sightings and strandings of small Cetacea on the coasts of France.
M7.	W. H. Lear and O. Christensen	Bycatches of harbour porpoises (*Phocoena phocoena*) in salmon drift-nets at West Greenland in 1972.
M8.	M. C. Mercer	The interaction between the Northern pilot whale (*Globicephala melaena*) and the short-finned squid (*Illex illecebrosus*) at Newfoundland with particular reference to stock assessments and production estimates.
M9.	I. Christensen	Preliminary report on the Norwegian fishery for small whales. The expansion of Norwegian whaling to Arctic and Northwest Atlantic waters, and Norwegian investigations of the biology of small whales.
M10.	W. F. Perrin	Distribution and differentiation of stocks of *Stenella* in the eastern tropical Pacific.
M11.*	T. Smith	A population projection matrix model for pilot whales.
M12.	J. Beckett	Porpoises and tuna purse seining: notes on Canadian involvement in the eastern Pacific.
M13.	M. Nishiwaki	Some certain ecological aspects of smaller cetaceans: the blue white dolphins (*Stenella coeruleoalba*) for the main example.
M14.	W. A. Walker	Mortality, selectivity, and techniques of live-capture fishery for smaller cetaceans off California, 1967–1973.
M15.	S. Ohsumi	A review of Japanese small-type whaling.
M16.	S. Ohsumi	Incidental catch of cetaceans with salmon gill net.
M17.	S. Ohsumi and Y. Masaki	Biological parameters of the Antarctic Minke whale in virginal population level.
M18.*	Y. Satake	Bibliography of small cetaceans in Japan (Provisional).
M19.	R. L. Brownell Jr.	Progress report on the biology of the Franciscana dolphin, *Pontoporia blainvillei*, in Uruguayan waters.
M20.	(D. C. Foote)	An investigation of small whale hunting in northern Norway.
M21.*	H. P. Castello (with C. Landaburu)	Bibliografia cetologica de Argentina, Uruguay y Brasil.
M22.	S. G. Brown	Marking of small cetaceans using "Discovery" type whale marks.
M23.	F. O. Kapel	Preliminary notes on the occurrence and exploitation of smaller Cetacea in Greenland.
M24.*	W. F. Perrin	Annotated bibliography of the genus *Stenella* (Cetacea, Delphinidae).

M25.	D. E. Sergeant	Identity, abundance, and present status of populations of white whales *Delphinapterus leucas* in North America.
M26.	J. G. Mead	Preliminary report on the former net fisheries for *Tursiops truncatus* in the western North Atlantic.
M27.*	M. C. Mercer	Status of whale stocks fished at Newfoundland.
M28.*	C. Roux	Documents on French tuna fishing vessels and fishing effort.
M29.*	I. Christensen	Sightings of marine mammals in the North Atlantic during the summer 1973.
M30.	A. Aguayo L.	Progress report on small cetaceans research in Chile.
M31.	A. W. Mansfield, T. G. Smith and B. Beck	The Narwhal *Monodon monoceros.*
M32.	M. A. Bigg and A. A. Wolman	Live-capture killer whale fishery, British Columbia and Washington, 1962–1973.
M33.*	D. Lluch B.	Status of smaller cetacean harvesting in Mexico.
M34.*	E. Mitchell	Porpoise, dolphin, and small whale fisheries of the world: definition of the problem.
M35.*	T. Ichihara	Biotelemetry.
M36.*	D. H. Brown	Comments on smaller Cetacea around Australia and New Guinea.
M37.	S. G. Brown	The relation between stranding mortality and population abundance of smaller Cetacea in the northeast Atlantic ocean.
M38.*	D. E. Gaskin	University of Guelph research programme on *Phocoena phocoena.*
M39.*	H. P. Castello	Current cetological investigations in Argentina.
M40.*	W. F. Perrin and D. B. Holts	Summarized distribution data for *Stenella, Delphinus*, and *Tursiops* in eastern tropical Pacific, through 1973.
M41.*	C. Roux	Some additional information on sightings and strandings for the coasts of France.
M42.*	R. L. Brownell Jr. and R. Praderi	Incidental catches of small cetaceans in coastal western South Atlantic waters.
M43.	E. Mitchell and V. M. Kozicki	Autumn stranding of a North Atlantic bottlenose whale, *Hyperoodon ampullatus*, in the Bay of Fundy, Nova Scotia.
M44.*	W. F. Perrin	Forms and field instructions used in porpoise observer program.
M45.*	R. L. Brownell Jr.	Catch statistics of Brazilian minke whale fisheries.
M46.*	M. Nishiwaki	Suggested scheme for conducting international research on small cetaceans.
M47.	E. Mitchell and V. M. Kozicki	Supplementary information on minke whale from Newfoundland fishery.
Received later:		
M48.	D. K. Caldwell and M. C. Caldwell	The dolphin and small whale fisheries of the Caribbean Sea: occurrence, history, biology and catch statistics — with special reference to the island of St. Vincent.
M49.	G. J. B. Ross, P. B. Best, and B. G. Donnelly	New records of the pygmy right whale *Caperea marginata* from South Africa, with comments on distribution, migration, appearance and behavior.

Editor's note – M1 and M2 were combined for publication, documents marked with an asterisk were not published, are published elsewhere (e.g. docs. M24, M27, M28, M29, M34, M45), or are included verbatim in the body of the Report (e.g. M35).

Appendix D

List of Attendees

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Appendix E

CETACEAN DATA RECORD (FORMS)

Cetacean Data Record
(Long Form)

catalog no. _____

field no. _____

Species _____ Sex _____ length _____

observer _____ date, time of death _____ of data _____

locality _____

_____

photographs or drawings _____

circumstances, cause of death, etc. _____

_____

external description (pigmentation, scars) _____

_____

tooth or baleen counts: upper l. _____ upper r. _____ lower l. _____ lower r. _____

diameter largest tooth, length longest baleen plate _____ color of baleen _____

_____

number of throat or ventral grooves (count latter between flippers) _____

MEASUREMENTS (specify units of measure used _____)

(3)	snout to apex of melon	(15)	projection lower/upper jaw
(9)	snout to center of blowhole(s)		rostral width at apex of melon
(2)	snout to center of eye	(24)	height of eye opening
(4)	snout to angle of mouth		length of eye opening
(5)	snout to ear	(6)	center of eye to ear*
(10)	snout to flipper	(7)	center of eye to angle of mouth*
(12)	snout to center of umbilicus		eye to blowhole edge (right)*
(16)	snout to end of ventral grooves		eye to blowhole edge (left)*
(13)	snout to genital slit (center)	(27)	blowhole length _____ width*
(14)	snout to anus	(28)	diameter ear opening r. _____ l.
(1)	total length, snout to notch		diameter of head between eyes*
(11)	snout to tip of dorsal fin	(20)	length of throat grooves
	fluke notch to anus	(29)	flipper length, anterior*
	notch to center genital slit	(30)	flipper length, posterior*
	fluke notch to umbilicus	(31)	flipper width, maximum*
	fluke notch to dorsal fin center	(25)	length mammary slits r. l.
	fluke notch to dorsal fin tip		number of mammary slits
	girth at eye	(26)	length genital slit anal slit
(21)	girth at axilla		perineal length (males)

(22) maximum girth _____ (34) fluke width* _____

23) girth at anus _____ (35) fluke depth* _____

girth midway anus to fluke notch _____ (36) depth of fluke notch _____

height, same place* _____ (32) dorsal fin height* _____

Thickness, same place* _____ (33) length dorsal fin base _____

blubber thickness: middorsal _____ midlateral _____ midventral _____

mammary gland: color _____ length _____ width _____ depth _____

lactating? _____ pregnant? _____ sperm in epididymus? _____

uterine condition _____ vaginal mucous? _____

fetus: length _____ weight _____ sex _____ flat diameter uterine horn r. _____ l. _____

diameter largest corpus luteum _____ number corpora lutea _____ corpora albicantia _____

gonads: weight r. _____ l. _____ dimensions (L × W × D) r. _____ l. _____

vertebral epiphyses: open _____ mm; closed, visible _____ closed, invisible _____

length of intestine _____

Weights (specify units used _____)

intact carcass _____ lung right _____ stomachs, full _____

viscera _____ lung left _____ stomachs, empty _____

muscle _____ liver _____ intestines _____

bone _____ spleen _____ pancreas _____

blubber _____ kidney right _____ brain _____

heart _____ kidney left _____

Remarks on weights _____

skull length _____ skull width _____ length tooth or baleen row, upper _____ lower _____

vertebral count: cervical _____ thoracic _____ lumbar _____ caudal _____

number of sternal ribs _____ free ribs _____ diaphragmatic bone _____

Parasite checklist (check if present, no if absent, NE if not examined)

eye _____ cyamids _____ rectum _____ lungs _____

mouth _____ Penella _____ kidney tissue _____ heart _____

blowhole _____ diatoms _____ kidney duct _____ brain _____

genital slit _____ forestomach _____ liver _____ air sinuses _____

anal slit _____ mainstomach _____ bile duct _____ blubber (cysts) _____

appendages _____ pyloric stomach _____ uterus _____ muscle _____

barnacles _____ intestine _____ other (see remarks) _____

Specimen collection checklist (indicate preservative in blank)

teeth or baleen _____	ear plugs _____	liver sample _____	skeleton _____
stomach contents _____	ectoparasites _____	kidney sample _____	X-rays _____
gonads _____	endoparasites _____	brain cultures _____	other _____
mammary gland _____	blubber sample _____	fetus _____	_____
uterine mucosa _____	muscle sample _____	skull _____	_____

Stomach contents (distinguish fore-, main-, and pyloric; describe condition and quantity)

_____

_____

_____

Remarks _____

_____

_____

_____

_____

INSTRUCTIONS. The measurements are arranged for convenience, starting from the head, with those requiring two persons coming first. All measurements, except those marked with a *, are taken in a straight line parallel to the body axis. The marked ones are taken point to point. Indicate if done otherwise. Measure to the centers of the apertures. Fill out separate form for fetuses. Photographs are very important. Tissue samples to be frozen or in 10% formalin. Stomach contents in alcohol only. Measurement numbers indicate equivalency with Norris (ed. 1961).

Cetacean Data Record

(Short Form)

Species _____ Sex _____

Observer _____ Date and time _____

Locality (latitude and longitude, if available) _____

_____

_____

Description of circumstances _____

_____

Tooth or baleen counts: upper L. _____ upper R. _____

lower L. _____ lower R. _____

Diameter largest tooth, length largest baleen plate _____

Color of baleen _____

Throat grooves present? _____ fluke notch present? _____

Lower jaw longer than upper? _____

Measurements — specify units of measure used _____

_____

A. Total length, snout to fluke notch _____

B. Tip of snout to beginning of dorsal fin _____

C. Length of beak _____

D. Fluke notch to anus _____

E. Fluke notch to center of genital slit _____

F. Flipper length_____

G. Fluke width _____

Remarks _____

INSTRUCTIONS. The locality should be described as accurately as possible, using references to permanent landmarks for strandings. At sea it will be necessary to use latitude and longitude or, if near the coast, a range and bearing from a prominent landmark. Describe the circumstances under which the information was collected (e.g. single or mass stranding, entangled in gillnet, captured at sea, etc.). In counting teeth, be sure to include the very small teeth at the back and front of the tooth row. The measurements are made as indicated in the drawing below. All measurements are taken in a straight line, and all except F and G are taken parallel to the long axis of the body (as indicated in the drawing). All of the blanks should be filled in. If a portion of the animal is damaged, or the measurement was not taken, so indicate. Under remarks, include any items such as injury, parasites, abnormal coloration, etc. Drawings or photographs of the animal are extremely useful. The blank space on the front is for drawings. The most useful view is a full side view, followed by closeups of the head, flippers, underside of the animal, flukes, and dorsal fin. [Editor's note – Drawing referred to is a modification of Norris (ed.) 1961, fig. 1.]

Appendix F

References

Most of the papers cited below were used for sources during the Montreal meeting, were contained in sources used, or were discussed during meetings of the various subgroups when writing the text of the report. Additional references will be found in Mitchell (1975) and Truitt (1974).

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Supplementary Information on Minke Whale (*Balaenoptera acutorostrata*) from Newfoundland Fishery[1]

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MITCHELL, E., AND V. M. KOZICKI. 1975. Supplementary information on minke whale (*Balaenoptera acutorostrata*) from Newfoundland fishery. J. Fish. Res. Board Can. 32: 985–994.

Minke whales (*Balaenoptera acutorostrata*) segregate by age and sex in the inshore waters of Newfoundland. The fishery in Trinity Bay exploited primarily juvenile males and females and pregnant females. Sexual maturity in females is at 24 ft (7.3 m) long and 7.3 earplug growth layers. Over 85% of mature females sampled were pregnant, three were lactating concurrently. A maximum of 14 growth layers was found in earplugs sampled. The ovulation rate was calculated at 0.6 corpora per growth layer. A von Bertalanffy growth curve was fitted to the data.

MITCHELL, E., AND V. M. KOZICKI. 1975. Supplementary information on minke whale (*Balaenoptera acutorostrata*) from Newfoundland fishery. J. Fish. Res. Board Can. 32: 985–994.

Les petits rorquals (*Balaenoptera acutorostrata*) se séparent selon l'âge et le sexe dans les eaux littorales de Terre-Neuve. La pêcherie de la baie Trinité exploite surtout les jeunes mâles et femelles, et les femelles enceintes. La maturité sexuelle chez les femelles est atteinte à une longueur de 24 pieds (7.3 m) de longueur et à 7.3 couches de croissance du tampon auriculaire. Plus de 85% des femelles mûres examinées étaient enceintes, trois allaitant en même temps. Nous avons trouvé un maximum de 14 couches de croissance dans les tampons auriculaires examinés. Le taux d'ovulation a été calculé comme étant 0.6 corpora par couche de croissance. Nous appliquons une courbe de croissance de von Bertalanffy aux données.

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MINKE whales (*Balaenoptera acutorostrata*) have been fished in the North Atlantic for tens of years. Biological data resulting from study of specimens available in the Norwegian nearshore and pelagic fishery have been presented by Jonsgaard (1951, 1962). A smaller fishery pursued mainly from the shores of Newfoundland since the mid 1940s has yielded specimens that have been examined by biologists (Sergeant 1963; Mitchell 1974a, 1974b). The present paper continues the analysis of biological information from the more recent Newfoundland sample (Mitchell 1974b).

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974; also circulated as document SC/26/34 at IWC Scientific Committee, London, June 1974.

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Sample

Aspects of the sample have been described by Mitchell (1974b). Catches were made by one to three local boats in a given season. They hunted only on good weather days, and returned to shore at the end of each day. The whales killed were delivered to the Dildo whaling station, which was mainly employed in a fishery for fin whales (Mitchell 1974a). There were no quotas or minimum size limits in the minke whale fishery. The increase of catches through 1972 (Table 1) reflects increasing interest in the fishery by the operators of the small, independent catcher boats.

The sample is from one highly localized concentration of minke whales (Fig. 2), representing one stock unit. The white flipper band (Fig. 9) occurred on every whale landed at Dildo, and is apparently diagnostic of *Balaenoptera acutorostrata* (sensu stricto) in the northern hemisphere. It is strikingly visible even under water, in the wild (Beamish and Mitchell 1973, fig. 8).

The presence, extent, and shape of the white flipper band may prove to be a useful means of distinguishing stocks of minke whales. The shape and width

TABLE 1. Length data in feet, and other parameters, of male, female, and total catch examined of minke whales at the South Dildo, Newfoundland whaling station during the period 1965–72. (Data on 28 minke whales landed at Williamsport, Nfld. and Blandford, N.S. are also included.) Whales were measured to the nearest 6 inches (152 mm), rounded off the nearest foot. Figures are given in feet (only) for the following parameters in the total sample examined by FRBC: n = number of whales examined; $\bar{x}$ = arithmetic mean length in feet; SE = standard error of the mean; SD = standard deviation from the mean.

SOUTH DILDO MINKE

	1965	1966	1967	1968	1969	1970	1971	1972	ALL YEARS
CANADIAN SEASON	1 IV to 30 IX	1 IV to 30 IX	1 V to 31 X	1 V to 31 X	1 V to 31 X	1 V to 31 X	1 V to 31 X	1 V to 31 X	———
CATCHERS OPERATING	V to IX	V to VIII	VI to VII	0	V to IX	V to VII	V to VII	V to IX	———
% TIME CATCHERS OPERATING	≈100	≈67	≈33	———	≈83	≈50	≈50	≈83	———
QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA
NUMBER KILLED	NO DATA	30	NO DATA	0	50	86	76	96	———
NUMBER LOST	NO DATA	0	0	0	0	0	0	0	0
NUMBER LANDED	*29	30	NO DATA	0	50	86	76	96	———
NUMBER REPORTED IN I.W.S	29	28	25	0	50	86	72	96·1	386·1
% QUOTA TAKEN	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA	NO QUOTA
NUMBER EXAMINED BY F.R.B.C.	0	17	0	0	10	16	53	95	191
% EXAMINED BY F.R.B.C.	0	56.7	0	———	20	18.6	69.7	98.9	———

IN THE SAMPLE EXAMINED BY F.R.B.C.

FREQUENCY

LENGTH IN FEET	Σ	♀	♂	Σ	♀	♂	Σ	♀	♂	Σ	♀	♂	Σ	♀	♂	Σ	♀	♂	Σ	♀	♂	Σ	%f	♀	%f	♂	%f
30																											
29																			1	1		1	0.5	1	0.7		
28				1	1																	1	0.5	1	0.7		
27										1	1					4	2	2	1	1		6	3.1	4	2.8	2	4.1
26				2	2					1	1		1	1		6	5	1	2	2		12	6.3	11	7.7	1	2.0
25				2	2								1	1		7	6	1	8	7	1	18	9.4	16	11.2	2	4.1
24				3	2	1				1	1		1		1	2	2		17	16	1	24	12.6	21	14.8	3	6.1
23				2		2				2	1	1	3	1	2	5	3	2	13	11	2	25	13.1	16	11.3	9	18.4
22				1	1								3	3		6	3	3	9	7	2	19	9.9	14	10.0	5	10.2
21				2		2				1	1		4	2	2	7	5	2	7	5	2	21	11.0	13	9.2	8	16.3
20										1	1		1	1		6	3	3	7	6	1	15	7.9	11	7.7	4	8.2
19				2	1	1							1	1		4	4		5	1	4	12	6.3	7	4.9	5	10.2
18										2	2		1	1		3	2	1	8	7	1	14	7.3	12	8.5	2	4.1
17				1		1										2	1	1	9	6	3	12	6.2	7	4.9	5	10.2
16																1	1		6	4	2	7	3.7	5	3.5	2	4.1
15				1	1					1	1								1		1	3	1.6	2	1.4	1	2.0
14																			1	1		1	0.5	1	0.7		
n				17	10	7				10	9	1	16	11	5	53	37	16	95	75	20	191		142		49	
$\bar{x}$				22.5	23.4	21.1				21.5	21.3	–	21.9	21.7	22.4	22.3	22.4	22.1	21.2	21.7	19.6	21.7		21.9		21.0	
SE				0.8	1.2	0.9				1.2	1.3	–	0.5	0.7	0.6	0.4	0.5	0.7	0.3	0.4	0.6	0.2		0.3		0.4	
SD				3.4	3.8	2.5				3.8	4.0	–	2.1	2.4	1.3	3.0	3.1	3.0	3.2	3.2	2.9	3.1		3.2		2.9	
MEDIAN				23	24.5	21				23	21	–	22	22	23	22	22	22	22	23	19	22		22		21	
MODE				24	—	—				$^{18}_{23}$	18	–	21	22	–	$^{21}_{25}$	25	$^{20}_{22}$	24	24	19	23		24		23	
RANGE				13	13	7				12	12		8	8	3	11	11	10	15	15	10	15		15		12	
% ♀				58.8						90.0			68.8			69.8			78.9			74.3					

BLANDFORD	Σ 12 FROM I.W.S.	0	Σ 15 FROM I.W.S.	0	0	0	0	0	27
WILLIAMSPORT	0	0	0	0	0	0	0	1(18'9)	1

*FIGURE OBTAINED FROM WHALING STATISTICS-NEWFOUNDLAND-1965-ECONOMICS BRANCH, DEPT. OF FISHERIES OF CANADA, ST. JOHN'S NFLD. 6.1.66

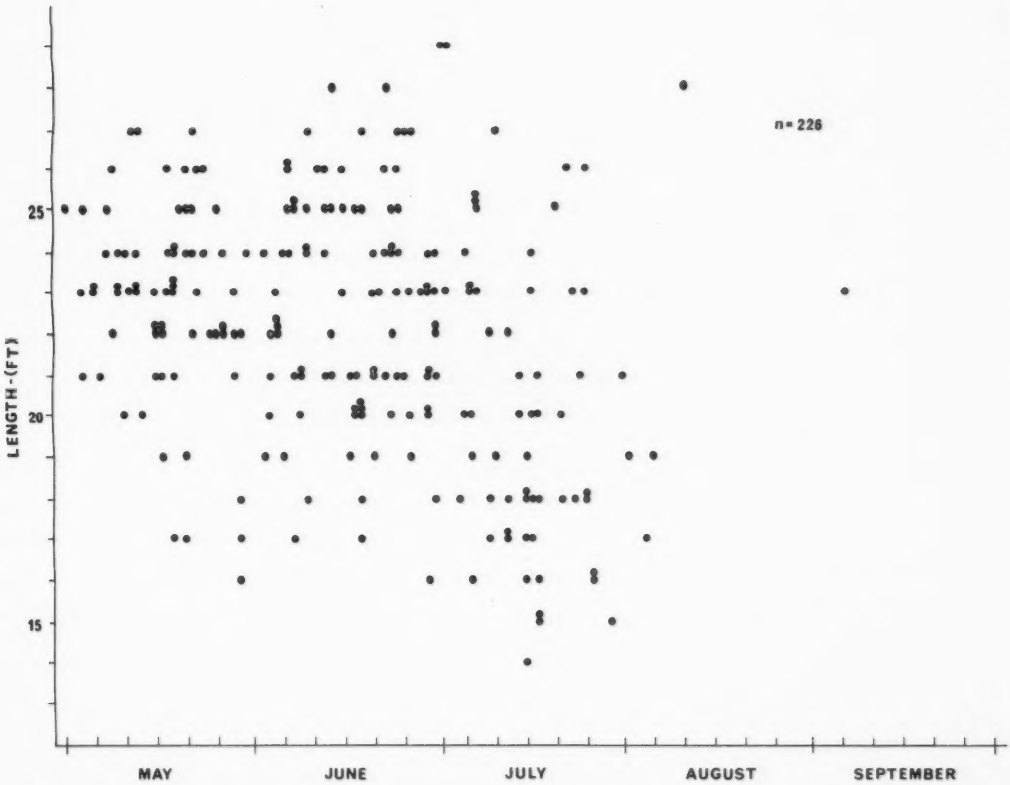

FIG. 1. Plot of time of catch of 226 male and female minke whales (*Balaenoptera acutorostrata*), landed at South Dildo, Newfoundland, 1966–72. Length of whale in feet is graphed against day of the season.

varies. The distal margin of the flipper band is often irregular, grading into the dark pigmentation of the distal half or third of the flipper, sometimes in swirls and streaks (Carl 1946, fig. on p. 48). The proximal margin of the flipper band is usually sharply defined. It is usually straight or broadly curved in specimens from the northeast Atlantic (e.g. Foote, fig. 30, this volume) and the northwest Atlantic (e.g. Report, fig. 2, this volume; Moore and Palmer 1955, pl. 1; Sergeant 1963, fig. 3; and our Fig. 9). However, the proximal margin usually has a slight, proximal projection of the white band in animals from the northwest Pacific, as pointed out by Omura and Sakiura (1956, p. 3, pl. 2; but see pl. 4 of Kimura and Nemoto 1956). This is also usually the case with minke whales from the northeast Pacific (e.g. Cowan 1939, pl. 1–2; Scheffer and Slipp 1948, fig. 50; Norris and Prescott 1961, pl. 39). In the southern hemisphere, some minke whales with white flipper bands apparently have been observed (e.g. Taylor 1957, p. 325–326; Kasuya and Ichihara 1965, p. 41; Gaskin 1972, p. 79) but most taken in commercial catches do not have a distinct band (e.g. Williamson 1959, pl. 1; Kasuya and Ichihara 1965, fig. 3; Ohsumi et al. 1970, pl. 1; Wise 1970, facing p. 176; and see Gaskin 1968, fig. 18 and Lillie 1915, pl. 5).

Catch Through Time

The 6-mo catching season in northeast Newfoundland waters usually started on the first of May, but the date fluctuated somewhat for between 2 to 4 wk over the period 1966–72 (Table 1).

In all of the years for which we have adequate sampling, the catch of whales terminated around the first of August. Only sporadic catches were made after this date, which generally marks the last appearance of minke whales inshore in northeast Newfoundland. A simple hypothesis is that minke whales follow capelin into the bays of Newfoundland and, after spawning capelin move offshore, the minke whales evidently follow offshore, or northward to the next, possibly later

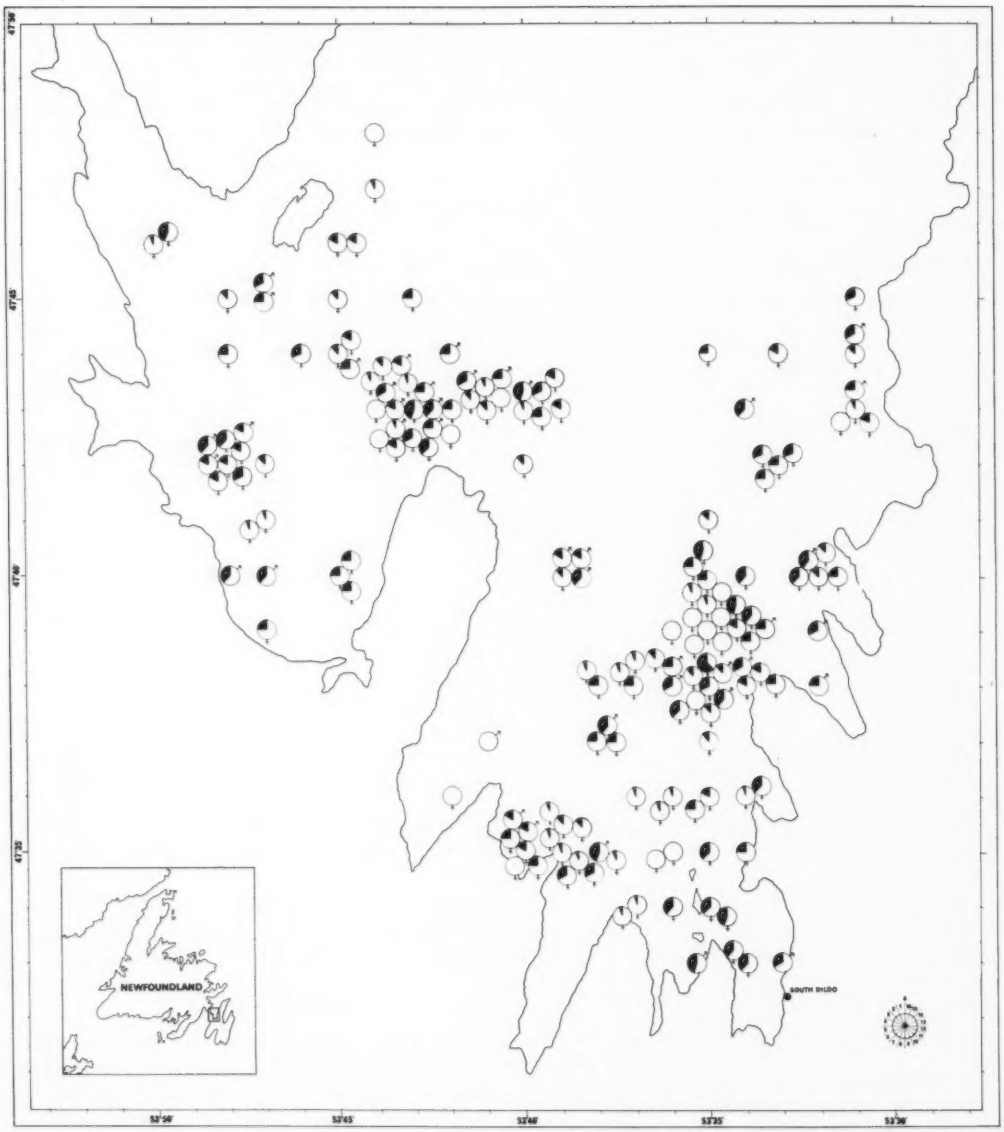

FIG. 2. Distribution of catch of minke whales in Trinity Bay, Newfoundland, landed at South Dildo, 1966–72. Sex of each whale is indicated. Time divisions of circles are for 12 days each, beginning May 1, through November 8.

spawning group of capelin (see data in Templeman 1948, p. 52–58; and Jangaard 1974). Figure 1 shows that some small (20 ft [6.1 m] long or less) minke whales are caught, especially during the second half of July. Since there is little or no selectivity in the local fishery, this data can be interpreted to mean that younger animals remain in the embayments somewhat longer than the mature animals. Furthermore, the composition of the catch indicates that mostly juveniles of both sexes and pregnant females penetrate deep into Trinity Bay, where all of the catches are made.

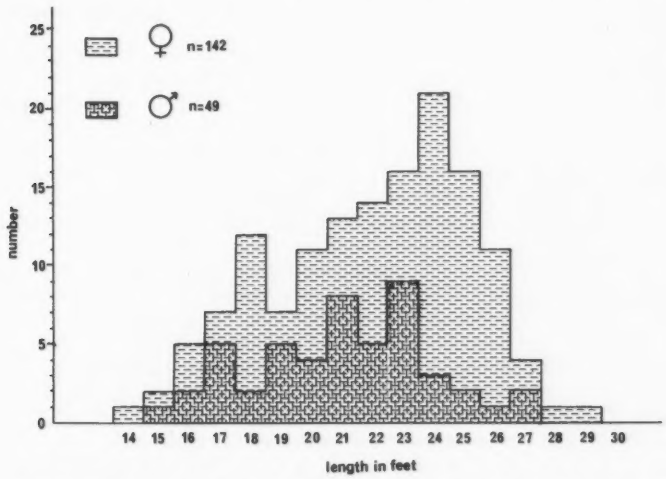

FIG. 3. Absolute number of minke whales in each length category examined in South Dildo, Nfld., 1966–72.

Geographical Distribution of Catch

Location of catches of minke whales are charted in Fig. 2. There is very little pattern to the distribution of the catch by month, by length category, or by sex. Apparently the fishery was opportunistic and there was little or no gunner selection, the gunners taking the first whale they encountered. Whale catches are concentrated around headlands, possibly reflecting localized groupings of whales around areas of high food density.

Length-Frequency of Catch

The sample of 142 female minke whales examined (Table 1) is distributed over a wide range of body lengths. This indicates that there was little selection by gunners in the Dildo minke whale fishery (Fig. 3, 4). Male catch distribution (Fig. 3, 4) is much more erratic. This is evidently due to the small sample size of 49 male whales. Lengths from 15 to 27 ft (4.6 to 8.2 m) are represented.

Sexual Maturity of Males

From the very limited sample of male testes that we have examined histologically, we find that over 90% of the males are not sexually mature. The very few (2) animals that were judged to be sexually mature showed a lack of sperm, indicating that the catching season (May–July) is outside a possible rutting season for the population sampled, or that mating takes place somewhere else (see below, under female sexual maturity). There is some information on the rutting season. It appears to precede the fishing season by a few months, based on the overall pattern of fetal growth (Mitchell 1974b; four pregnant females captured in mid- to late May had fetuses less than 10 mm in length).

Sergeant (1963, p. 1498) concluded that all of 12 males he examined (five histologically) were sexually mature. His subsample ranged from 23 (7 m) to 27 ft (8.2 m) (mean 25 ft [7.6 m]), and was caught mainly in July (9 of 12). In Sergeant's total sample landed (1963, fig. 4), approximately half of the males were 23 ft (7 m) or more in length (the maximal length of immatures, based on testes weight; Jonsgaard 1951; Mitchell 1974b, fig. 2). Our landed sample of males ($n = 49$) averaged 21.0 ft (6.4 m) in length, and only 16% were over 23 ft (7 m) in length.

Female Catch Composition

We have examined 123 pairs of ovaries collected from the whales landed. Of these, 42 of the females were considered sexually mature as they had at least one corpus albicans or corpus luteum present in the ovaries. Thus 34.1% of the sample were sexually mature. (Sergeant 1963, found 12 of 19 or 63% examined sexually mature, substantially more than in our sample.) Among 42 sexually mature females, 36 or 85.7% were pregnant. (Sergeant found 11 of 12 pregnant.)

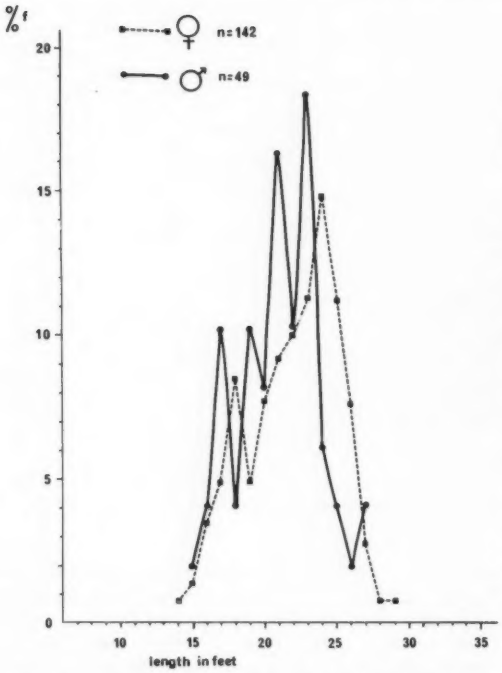

FIG. 4. Percentage frequency of length categories of minke whales examined at South Dildo, Trinity Bay, Nfld., 1966–72.

We examined 37 sexually mature females for lactation and determined that three were lactating. This represents 8.5% lactating females in the sample examined, all of which were pregnant at the same time. Lengths of fetuses were measured in two of the three cases where lactating whales were pregnant. Fetal lengths were 17 and 102 cm, respectively. The number of sexually mature but resting whales was determined to be 6 or 14.3% of the observed sample. These females had from 1 to 10 corpora albicantia present in their ovaries (actual counts were: 1, 1, 4, 6, 9, 10).

While length at sexual maturity may be similar in both early and late samples (Sergeant 1963; Mitchell 1974a; this paper), the samples are quite different. For 5 yr between 1966 and 1972, our sample was comprised of 74.3% females (also 68% females in 1967, data from commercial source); Sergeant's landed sample of 297 (1963, fig. 4) was composed of 52% females. Males comprise a smaller percentage of the later catch; and the mean length of males landed is less (Mitchell 1974b).

Earplug Sample

Because of the difficulties in collecting and processing the earplugs from minke whales, we found it useful to utilize the technique whereby the earplug is embedded in a paraffin block and then sectioned (e.g. Zemsky 1960). We have had moderate success with this technique.

From a sample of 49 male minke whales examined, we collected six pairs of earplugs and four single earplugs for a total of 10 animals sampled. Of 142 female minke whales examined, we collected 36 pairs of earplugs and 13 single earplugs, for a total of 49 whales in our sample. In this female sample, two earplugs were damaged, 13 earplugs were unreadable, and 35 plugs were readable. In the male sample two earplugs were damaged, five were unreadable, and three earplugs were readable.

In Fig. 5, the length frequencies of females on the catch curve is compared with the length frequencies of the sample of female whales used in aging. It is apparent that there is not undue bias. The age sample approximates the sample caught, with the exception of the younger animals, under 19 ft (5.8 m) in length.

Survivorship Curve for Females

Although the distribution of the female catch is relatively smooth and broad (Fig. 3, 4) indicating little gunner selection, the great majority of females captured are under 24 ft (7.3 m) in length. This length has been determined as an average for the attainment of sexual maturity in our sample. This is even more striking in the case of males, where some 90% of captured whales are under 24 ft in length. Since there is evidently a high natural mortality among juvenile minke whales, the supplementary high fishing mortality of young animals indicates heavy exploitation of the local population in Trinity Bay.

The greatest number of growth layers that we have observed in our sample is 14. This is relatively low compared to other samples of minke whales from the Norwegian catch in the eastern North Atlantic or from the Antarctic. The relatively high mortality of females from 4 to 7 or 8 growth layers, reflected in the mortality curve (Fig. 6), is due in part to high fishing mortality on this local population.

Sexual Maturity of Females

In our aged sample, we looked for whales having one corpus luteum or one corpus albicans

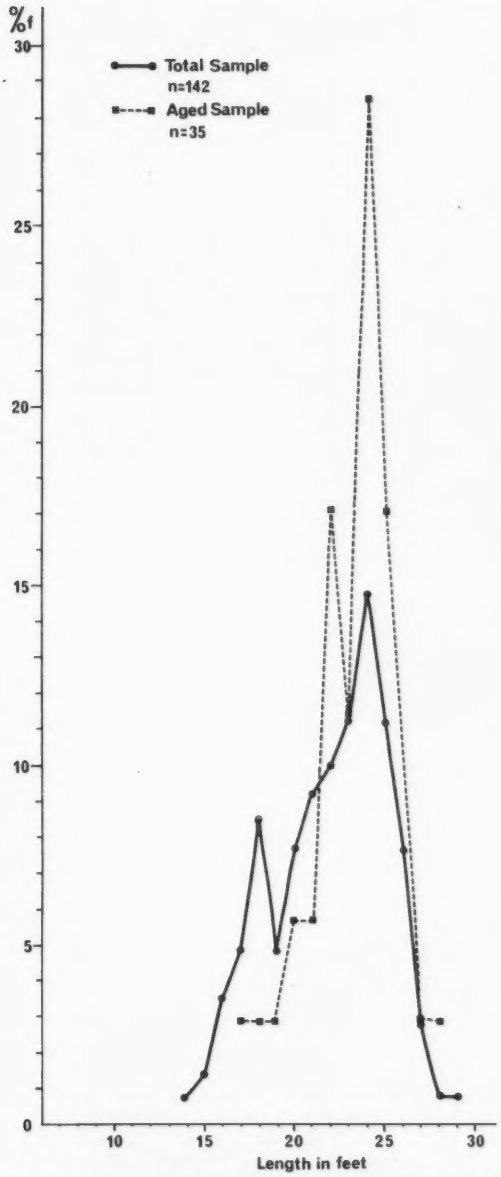

FIG. 5. Percentage frequency of length categories of female minke whales examined in catch, compared with same in subsample used for aging, South Dildo, Nfld., 1971–72.

of an early stage (stage A or B1). Six such females were in our aged sample (having growth layers of 7, 8, 5, 10, 6, and 8). The number of growth layers varied from 5 to 10 with a mean of 7.3

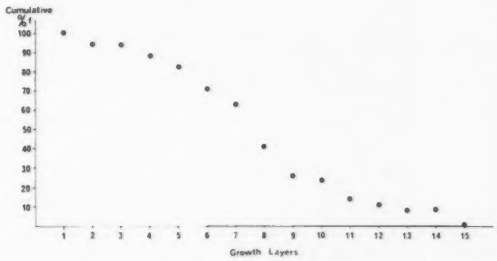

FIG. 6. Survivorship curve for 34 female minke whales, South Dildo, 1971–72 (same sample as in Fig. 5).

growth layers, for the age at first ovulation.

Corresponding lengths (25, 23, 25, 26, 24, and 24 ft) were from 23 to 25 ft, with a mean of 24.17 ft for the length at first ovulation. This is not much different from the lengths obtained by consulting the growth curve (below), and accords with earlier data from 19 females (Sergeant 1963, Table 2).

Our later sample (1966–72) contained more immature males and females than Sergeant's sample (1948, 1951–61). This might be due to a later continuation of the fishery in the 1966–72 period (e.g. in 1971–72, to September and October, Mitchell 1974b, table 5), or it might reflect overexploitation of large, mature whales.

Ovulation Rate

A linear regression of the combined total number of corpora albicantia and corpora lutea in both ovaries, versus the number of growth layers in earplugs, was found for the sample of females. The regression slope, or estimated mean rate of formation of corpora, for the 1971 and 1972 combined sample, is 0.6 corpora per growth layer (Fig. 7), with a coefficient of correlation of 0.71.

Von Bertalanffy Growth Model

The basic form of the von Bertalanffy growth curve

$$L_t(t) = L_\infty - (L_\infty - L_o)e^{-k(t-t_0)}$$

has been used with modification after Beverton and Holt (1957), to give an equation:

$$L_t = L_\infty\,(1 - e^{-k(t-t_0)})$$

It has to be remembered that because poor representation of very young animals in our sample has been documented, the growth model (Fig. 8) should be considered valid only for the postpuberal

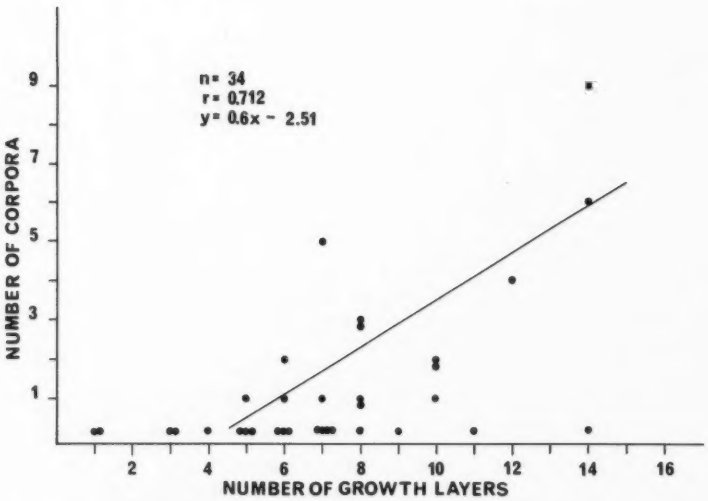

FIG. 7. Linear regression of growth layers in earplugs against number of corpora albicantia and lutea in both ovaries for sample of 34 female minke whales, South Dildo, 1971–72.

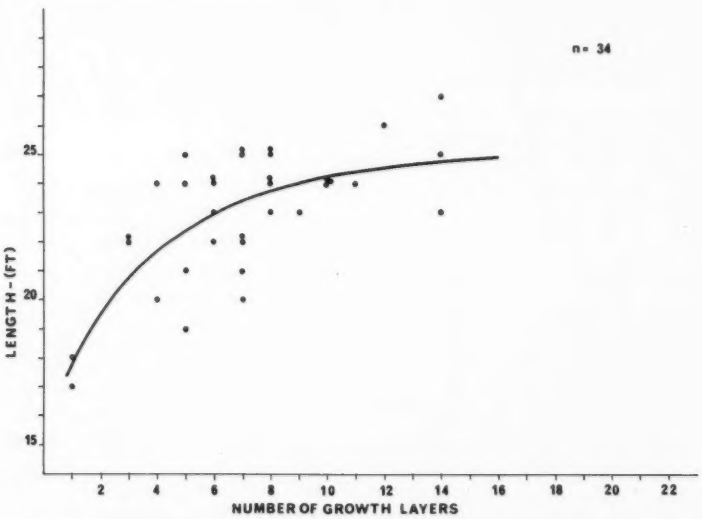

FIG. 8. Von Bertalanffy growth curve for female minke whales, South Dildo, 1971–72, based on limited sample of 34 whales.

individuals. Lack of very old animals also imposes the same limitation on the right hand limb of the curve.

The index of metabolic rate (k) is quite high as compared with our fin whale value for k (we found in female fin whales a value of 0.1–0.13). For minke whales the parameters are:

$L_\infty = 25$ ft

$k = 0.25$

$t_o = 3.2$ growth layers

$L_\cdot = 14$ ft ($t_o = 0$)

Unfortunately there are only three male minke

FIG. 9. Minke whales landed at South Dildo, showing aspects of pigmentation. a, Ventral view of 24-ft (720-cm) female, landed May 9, 1972 (D10-72). b, Right lateral view of head of 25-ft (750-cm) female, landed June 18, 1971 (D54-71). c, View of right flipper of 24-ft (715-cm) female landed June 12, 1972 (D58-72). The flipper patch is usually sharply demarcated proximally, more diffuse distally as in a and c. The white baleen often has plates interspersed with gray edges or streaks. (Photographs a-4:31, b-54:4, c-25:8, by J. G. Mead; see also fig. 1 and 2 in the Report, this volume.)

whales aged by growth layers in earplugs in our sample, and therefore it is impossible to draw any conclusions regarding growth of males from our data.

Acknowledgments

We acknowledge with gratitude the interest, aid, and enthusiasm of Mr A. Pivorunas of Yale University who has generously shared his time and ideas with us on the interpretation of our whale data. We are also indebted to Dr J. G. Mead of the Smithsonian Institution, who carried out excellent and consistent examination of minke whales in the Newfoundland fishery while associated with the Arctic Biological Station.

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Biological Parameters of the Antarctic Minke Whale at the Virginal Population Level[1]

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OHSUMI, S., AND Y. MASAKI. 1975. Biological parameters of the Antarctic minke whale at the virginal population level. J. Fish. Res. Board Can. 32: 995–1004.

New data from Japanese catches in Antarctic seasons 1971–72 and 1972–73 are used to calculate biological parameters. Determinations are: fetal sex ratio (52.0% females); sex ratio in catch (54.1% females); L_∞, males (27.9 ft), females (29.5 ft); age at asymptotic body length, males (18–20 yr), females (20–22 yr); male sexual maturity at testis weight (0.4 kg); length at beginning of sexual maturity, males (21 ft), females (24 ft) and at 50% sexually mature, males (23.6 ft), females (26.2 ft); age at sexual maturity, females (6 yr); apparent pregnancy rate (89.5%); annual ovulation rate (0.866); litter size (1.007); natural mortality coefficient of sexually mature sample (0.127) and of sexually immature sample (0.213); age at recruitment (6 yr); and rate of recruitment in virgin population (0.119).

OHSUMI, S., AND Y. MASAKI. 1975. Biological parameters of the Antarctic minke whale at the virginal population level. J. Fish. Res. Board Can. 32: 995–1004.

Utilisant de nouvelles données sur les prises japonaises de petits rorquals dans l'Antarctique au cours des saisons 1971–72 et 1972–73, les auteurs ont calculé les paramètres biologiques. Les mesures sont les suivantes: proportion des sexes des fœtus (52.0% femelles); proportion des sexes dans les prises (54.1% femelles); L_∞ mâles (27.9 pieds), femelles (29.5 pieds); âge à la longueur asymptotique du corps, mâles (18–20 ans), femelles (20–22 ans); maturité sexuelle des mâles à un poids du testicule (0.4 kg); longueur au début de la maturité sexuelle, mâles (21 pieds), femelles (24 pieds) et longueur à laquelle 50% des individus sont sexuellement mûrs, mâles (23.6 pieds), femelles (26.2 pieds); âge de la maturité sexuelle, femelles (6 ans); taux de grossesse apparent (89.5%); taux d'ovulation annuel (0.886); nombre par portée (1.007); coefficient de mortalité naturelle d'un échantillon d'individus sexuellement mûrs (0.127) et d'un échantillon d'individus immatures (0.213); âge de recrutement (6 ans); et taux de recrutement dans une population vierge (0.119).

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OHSUMI et al. (1970) reported preliminary investigations on the stock of the Antarctic minke whale sampled in the catches by Japanese whaling expeditions in the 1967–68 and 1968–69 Antarctic seasons. Several biological parameters, such as the natural mortality coefficient, the age at sexual maturity, the pregnancy rate, etc. were estimated in their paper, though the samples were not numerically large. A population model was attempted by Ohsumi and Masaki (1971), using these population parameters.

Full-scale pelagic catches of the Antarctic minke whale started from 1971–72, after the IWC Scientific Committee made a preliminary estimate of the population size, maximum sustainable yield, and population level (22nd Rep. IWC 1972). Much biological material has been obtained since then. We reexamine several biological parameters in this paper by use of the materials that were collected by Japanese expeditions, to confirm the values of these parameters in the virginal population level.

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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Materials

Japanese catches of minke whales in the Antarctic seasons, 1971–72 and 1972–73 are 3013 and 2092, respectively. The data used in this paper are mainly provided by the biological investigations on each whale caught in both seasons. Catch data in 1967–68, 1968–69, and 1973–74 (by the end of February, 1974) are also used in some sections.

Fishery-biological investigations and materials collected were described by Ohsumi (1972). Data collected include: date and position caught, sex, body length, fetus (sex and body length), lactation, thickness of mammary gland, weight of testes (measured on board factory ships), and the ovaries and earplugs were collected for examination in our laboratory.

TABLE 1. Female sex ratios of the Antarctic minke whales that were caught by Japan in 1967/68–1973/74 seasons (♀%).

Square	Nov.	Dec.	Jan.	Feb.	Mar.	Total
A14	—	—	23.8	0.0	—	20.0
A15	20.0	18.8	0.0	—	13.3	17.9
A16	—	—	0.0	—	—	0.0
A17	50.0	—	—	—	—	50.0
A28	—	—	—	14.3	—	14.3
B6	—	—	78.8	88.0	—	82.3
B7	—	—	91.4	73.1	—	84.7
B8	—	—	88.7	82.1	—	86.7
B9	—	—	88.3	66.7	—	87.6
B10	—	—	82.5	66.0	—	78.4
B11	—	—	72.3	70.6	—	71.3
B12	—	—	82.3	50.2	—	67.3
B13	—	85.9	86.0	56.2	—	69.1
B14	64.9	77.9	50.0	43.9	—	69.4
B15	40.9	39.0	40.7	39.2	—	40.1
B16	31.3	46.6	39.2	32.2	—	40.2
B17	27.0	75.5	80.6	—	—	74.6
B18	50.5	44.9	79.3	—	—	49.2
B19	57.4	45.7	77.4	—	—	53.1
C6	—	—	—	93.9	—	93.9
Total	52.9	54.4	72.3	56.5	18.8	59.5

Many other items, such as stomach contents, thickness of blubber, color patterns, etc. were also investigated, but these materials are not used in this paper.

Notation

The following notations are used in some equations in this paper:

ϕ: Size of age-class in number
h: Sex ratio of females at birth
l: Litter size
M: Natural mortality coefficient, after the age at sexual maturity
M′: Average natural mortality coefficient, during the sexually immature stage
m: Suffix of age at sexual maturity
p: Pregnancy rate
R_0: Recruitment in number at birth
R_m: Recruitment in number at age of sexual maturity
r: Recruitment rate or suffix of age at recruitment
S: Population size of sexually mature females
x: Age (years old, where one growth layer is taken to represent 1 yr)
Z: Total mortality coefficient

Sex Ratios

Sex Ratio in Fetal Stage

Excluding small fetuses less than 10 cm in body length for which determination of sex is difficult, the sex ratio of female fetuses is 52.0% among 1732 fetuses which were examined in samples from the 1971–72 and 1972–73 seasons. It is still difficult to estimate the sex ratio at birth, for large fetuses were not obtained in sufficient number (only 20 fetuses with body lengths longer than 110 cm) to confirm it, but a reasonable estimate is about 50% ($\delta : \varphi = 1 : 1$), as in other species of *Balaenoptera*.

Sex Ratios of Whales Caught

Very remarkable sexual segregations are observed in the Antarctic, as shown in Table 1. However, the distribution of the catch data has not yet covered all the Antarctic. It is estimated that females concentrate in higher latitudes, and sexual segregation is also observed longitudinally even in the same zone (especially in B-zone). Seasonal changes in the sex ratio are also seen in the same square (except square B14).

The total female sex ratios of the whales caught in 1967–68, 1968–69, 1971–72, and 1972–73 are 34.9, 21.5, 63.5, and 46.6%, respectively. The large variation among these figures is apparently due to the different whaling grounds in each season. The total female sex ratio during these four seasons is calculated to be 54.1%.

Age-Length Key and Growth Curve

Two sets of age-length keys are made, by sex with samples of 1404 females and 916 males for

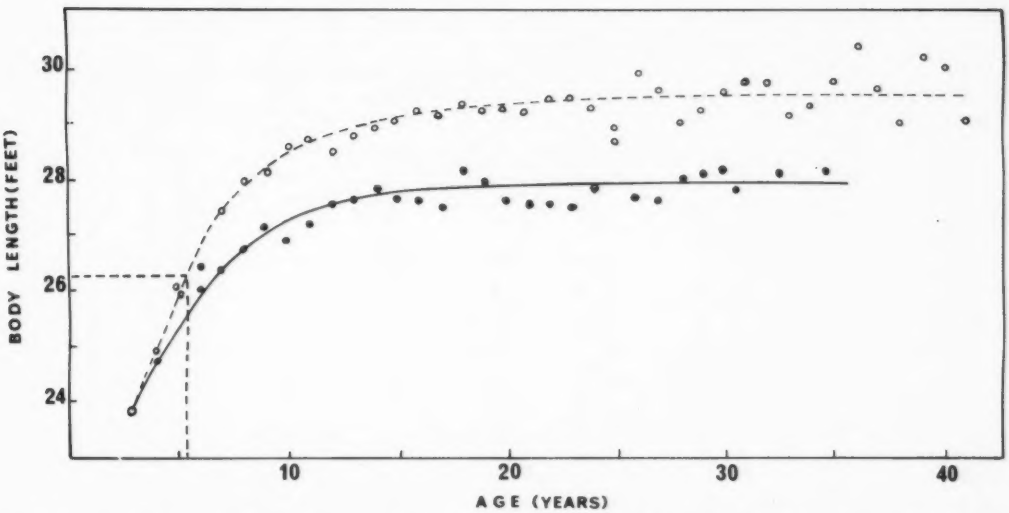

FIG. 1. Growth curves of the Antarctic minke whale by use of data from 1971–72 and 1972–73 seasons. Solid lines and closed circle: males; broken lines and open circle: females. Dotted line: age and body length at sexual maturity of females.

which ages were able to be estimated with counts of growth-layers in the earplug.

Average body lengths are calculated in each age-class, and growth curves are obtained by sexes as shown in Fig. 1. Due to the difficulty in collection and counting of earplugs of younger ages, growth curves in younger ages are thought to be insufficient. The maximum body lengths in the growth curves are 29.5 ft (9 m) and 27.9 ft (8.5 m), in females and males, respectively. Growth will stop in 20–22 and 18–20 yr of age in females and males, respectively.

Rate of Sexual Maturity

Determination of Sexual Maturity

Collected samples of testis tissues are being examined histologically, but we have not yet obtained the results. Ohsumi et al. (1970) estimated that 0.35 kg was the mean weight of one testis at sexual maturity, by examining the frequency distribution of testis weight. The same result was obtained in the present paper, re-examining the same kind of frequency distribution of whales caught in 1971–72 and 1972–73. Then, we can determine the sexual maturity of males from single testis weight, and the males in which the larger testis is 0.4 kg and over is regarded as a sexually mature male.

In the case of females, if an individual has one or more corpus luteum or corpus albicans in both ovaries, it is regarded as a sexually mature female, though some puberal females are included as sexually mature in this kind of identification.

Rate of Sexual Maturity of Whales Caught

Table 2 shows the percentage rates of sexual maturity of whales caught in the 1967–68 through the 1972–73 seasons. Although there is no legal size limit in the Antarctic minke whale, sexually mature rates of whales caught in the Antarctic are very high. Rates of sexual maturity in males are higher than in females in each square and in each month. Large variations are not observed among statistical squares. Seasonal changes are clearly found in both sexes and in each square, and they have a tendency to increase with months. This will mean that the migration season is different with age, and that younger age-classes are apt to reach to, and leave from, higher latitudes earlier than older whales.

Body Length at Sexual Maturity

Sexual maturity begins at 21 and 24 ft in males and females, respectively, and the largest sexually immature whales are 27 and 31 ft (8.2 and 9.4 m) in males and females, respectively. The change in rate of sexual maturity with body length is shown by sexes in Fig. 2. The body lengths at which 50% of individuals are sexually mature are estimated to be 23.6 ft (7.2 m) and 26.2 ft (8 m) in males and females, respectively.

TABLE 2. Percent rates of sexual maturity of the Antarctic minke whales that were caught by Japan in 1967/68–1972/73.

Square	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Males						
A14	—	—	96.9	100.0	—	97.4
A15	—	95.1	100.0	—	100.0	95.8
A16	—	—	100.0	—	—	100.0
B12	—	—	—	97.1	—	97.1
B13	—	—	—	100.0	—	100.0
B14	—	—	96.0	100.0	—	98.3
B15	—	96.0	95.6	100.0	—	96.2
B16	—	84.5	97.4	97.4	—	92.2
B17	—	90.6	86.5	—	—	88.8
B18	90.4	88.3	80.6	—	—	88.4
B19	86.4	90.5	—	—	—	89.9
Total	89.4	89.5	92.8	98.9	100.0	91.6
Females						
A14	—	—	70.0	—	—	70.0
A15	—	68.4	—	—	100.0	71.4
B12	—	—	—	79.2	—	79.2
B13	—	—	—	78.6	—	78.6
B14	—	—	74.0	87.0	—	80.8
B15	—	60.0	74.4	90.3	—	75.4
B16	—	55.2	83.7	90.1	—	82.9
B17	—	85.1	80.5	—	—	82.7
B18	68.7	70.7	71.8	—	—	70.6
B19	50.0	78.2	—	—	—	75.6
Total	63.9	76.4	78.3	86.6	100.0	78.3

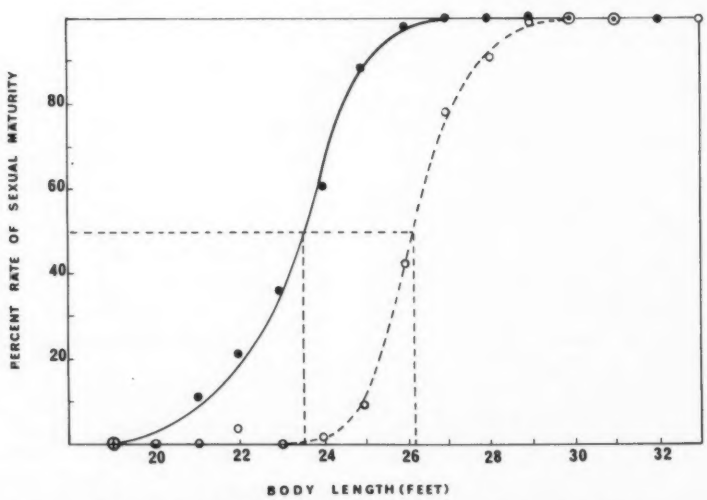

FIG. 2. Change in sexually mature rate of the Antarctic minke whale related to body length, 1971/72–1972/73. Solid line: males; broken line: females.

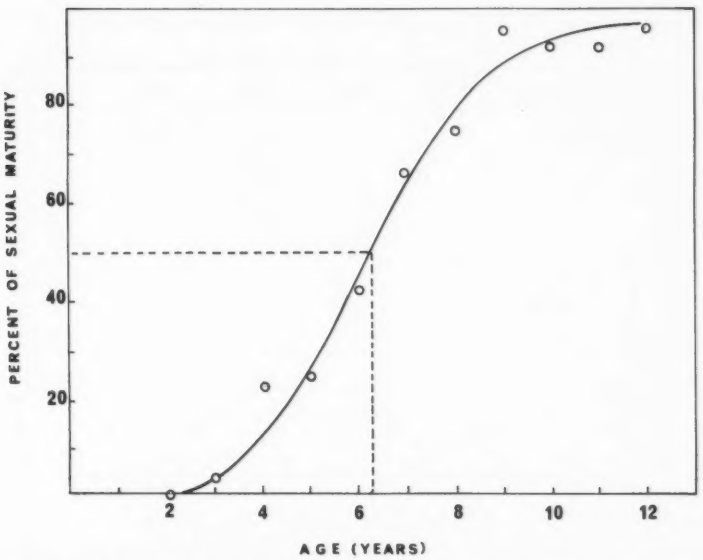

FIG. 3. Change in rate of sexual maturity of the Antarctic minke female whale related to age, 1971/72–1972/73.

These figures are 0.1 m longer than those of a preliminary estimate (Ohsumi et al. 1970). Above figures are regarded as the average body lengths of the Antarctic minke whale at sexual maturity.

Age at Sexual Maturity in Females

Age at sexual maturity in females is one of the basic biological parameters for population assessment. It is estimated by means of several approaches.

CHANGE IN RATE OF SEXUAL MATURITY WITH AGE

Figure 3 shows the change in rate of sexual maturity with age in females. Sexual maturity begins from 4 yr of age, and most individuals attain maturity by 9 yr, assuming that one growth layer accumulates each year in earplug, even in immature stages. The age when 50% of females are sexually mature is estimated from this figure to be 6.3 yr.

RELATION BETWEEN AGE AND CORPORA NUMBER

The relation between age and corpora number in ovaries is shown in Fig. 5. The age at which a linear regression line crosses a line of one corpus, regarded to be the beginning of the stage of sexual maturity, is 5.6 yr.

FROM GROWTH CURVE

The body length of females at sexual maturity was estimated (above) to be 26.2 ft (8 m). In Fig. 1, the age at which the female growth curve crosses a line of this body length is estimated to be 5.5 yr.

The above results, using three approaches, indicate that 6 yr will be the average age at sexual maturity of the females in the present stage of the population of the Antarctic minke whale. Ohsumi et al. (1970) made a preliminary estimate of the age at sexual maturity as 7–8 yr, but this must be changed now in the light of the new data above.

Pregnancy Rate

APPARENT PREGNANCY RATE

Table 3 shows the apparent pregnancy rates (percentages of pregnant females in the total sample of sexually mature females) of whales caught in the 1971–72 and 1972–73 Antarctic seasons, by months and by statistical squares.

The total apparent pregnancy rate is 89.5%. We did not find any clear, seasonal change in the pregnancy rate, though it seems to be somewhat lower in November and higher in March. Table 3 also shows that the pregnancy rates are almost

TABLE 3. Apparent pregnancy rates of the Antarctic minke whales caught in 1971–72 and 1972–73.

Square	Nov.	Dec.	Jan.	Feb.	Mar.	Total
A15	—	—	—	—	100.0	100.0
B12	—	—	—	90.5	—	90.5
B13	—	—	—	85.4	—	85.4
B14	—	—	97.3	97.9	—	97.6
B15	—	—	87.1	85.7	—	86.8
B16	—	—	87.8	90.3	—	88.9
B17	—	90.5	89.7	—	—	90.1
B18	87.3	89.7	90.5	—	—	89.5
B19	60.0	90.0	—	—	—	88.1
Total	88.1	90.1	89.7	89.2	100.0	89.5

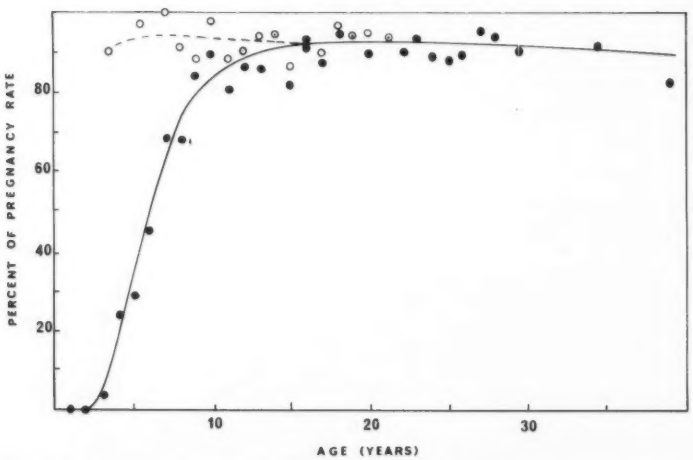

FIG. 4. Change in apparent pregnancy rate of the Antarctic minke whale related to age, 1971/72–1972/73. Solid line and closed circles: of total females; broken line and open circle: of sexually mature females.

similar in each square, at least in B-zone. We do not yet have sufficient materials to examine the latitudinal change in pregnancy rates. The above figures of pregnancy rates should not be regarded as the true pregnancy rates, for reproductive segregation must be considered.

It is notable that no lactating females were caught in the higher latitudes of the Antarctic (Ohsumi 1972).

CHANGE IN APPARENT PREGNANCY RATE ACCOMPANIED WITH AGE

Laws (1961) suggested that the younger females are perhaps slightly less fertile, and that fertility may decline again in the very old age group in the fin whale, but Gambell (1968) did not find such a systematic change in the sei whale.

Figure 4 shows changes in the pregnancy rate related to age in the Antarctic minke whale. In the case including sexually immature females, the pregnancy rate increases rapidly around the age at sexual maturity, and attains the maximum at 16 yr of age. However, when we deal only with sexually mature females, the pregnancy rate is high even in younger ages, and it has a peak at 7 yr of age. Although the pregnancy rate has a tendency to decrease gradually, it is almost constant, at a very high level.

OVULATION RATE

Figure 5 shows the change in the average number of corpora in both ovaries by age, using an age-ovulation key based on the whales caught in

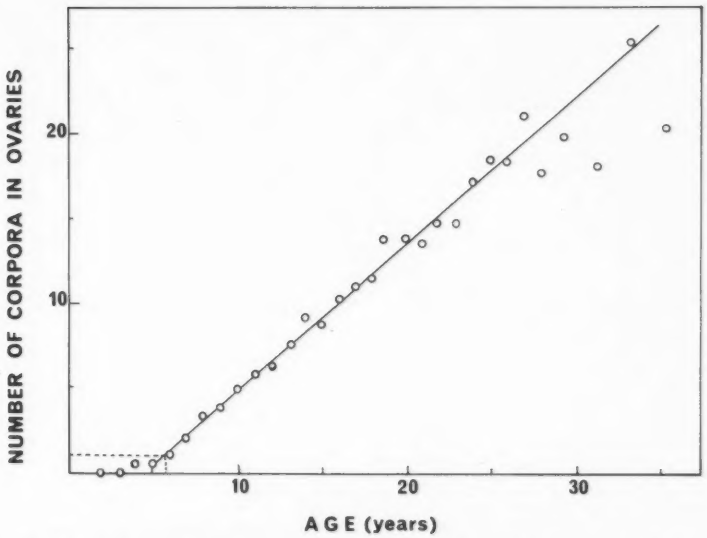

FIG. 5. Accumulation of corpora in both ovaries related to age of the Antarctic minke whales caught in 1971–72 and 1972–73. Open circle: average number of corpora in each age category.

1971–72 and 1972–73. The number of whales used in making this key is 1359.

A calculated regression line ranges from 6 to 28 yr of age. The correlation coefficient is 0.988, and the line is represented to be:

$$Y = 0.866\,X - 3.86$$

Where, X is age, and Y is number of corpora lutea and albicantia in both ovaries.

This equation means that the annual ovulation rate is almost constant from 6 to at least 28 yr of age, and the annual rate is 0.866. This figure is higher than the preliminary result of 0.767 by Ohsumi et al. (1970), and is almost the same as the result (0.853–0.970) by Masaki (1973).

True Pregnancy Rate

It is still very difficult to estimate the true pregnancy rate in the Antarctic minke whale, for the materials were obtained from only the high latitudes, and some reproductive segregation is observed in these waters.

The present ovulation rate is estimated to be 0.866, and so the true pregnancy rate should be less than this figure. According to Gambell (1968), the ovulation rate of the southern sei whale is 0.69 per annum, and the pregnancy rate is the same figure. Then, the true pregnancy rate of the Antarctic minke whale may not necessarily be so far from the figure for the annual ovulation rate. We then here estimate the true pregnancy rate to be 0.85, though further study of this parameter is needed.

Litter Size

Among 1998 pregnant females for which the sex of fetuses was identified, 13 females had twin fetuses. Although litter size is not always the same as the rate of occurrence of multiplets in fetal stages, the multiplet index is calculated to be 0.65%.Then, litter size is estimated to be about 1.007. This figure is lower than that for other species of *Balaenoptera*.

Natural Mortality Coefficient

From Age Composition

The age distributions of the Antarctic minke whales caught in the 1971–72 and 1972–73 seasons are shown in Fig. 6, separately by sexes.

It is reasonable to consider that the present population is at the virginal level, and then the total mortality coefficient, Z, is the same as natural mortality coefficient, M. The figure of Z is calculated from the age composition as the gradient of the regression line.

Table 4 shows the results of our calculation of M. It can be estimated that M is to be regarded

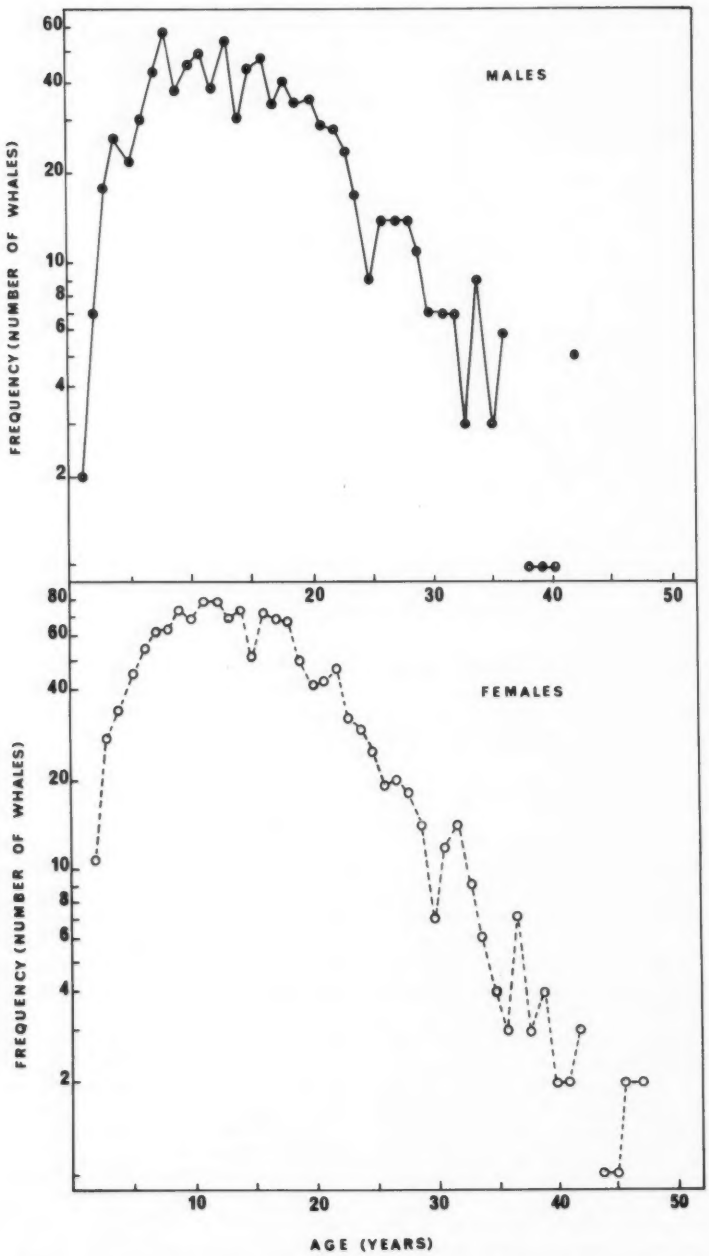

FIG. 6. Age distribution of the Antarctic minke whales caught in 1971–72 and 1972–73 seasons.

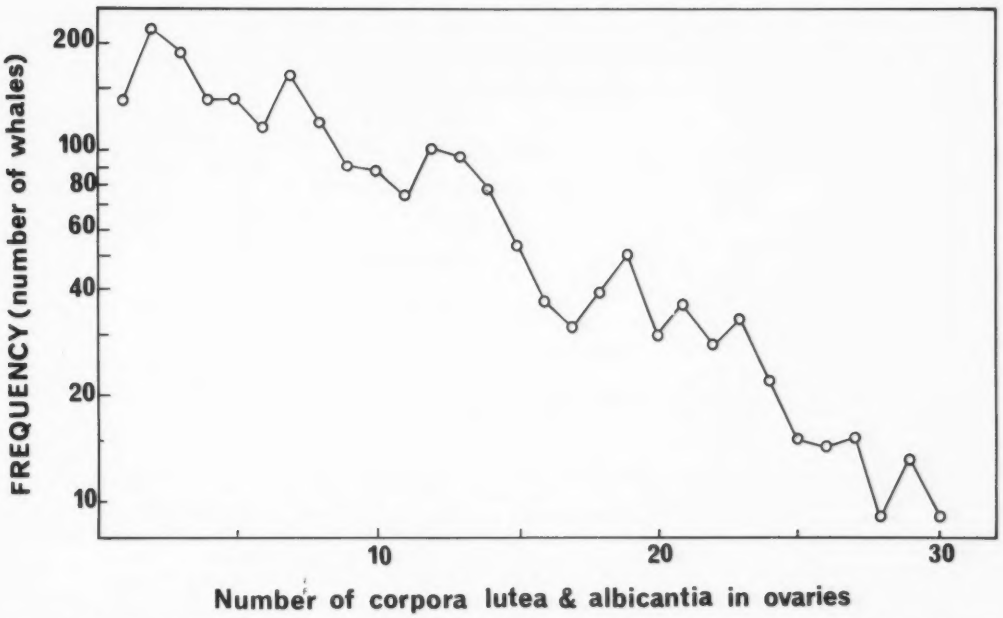

FIG. 7. Frequency distribution of corpora number in both ovaries of the Antarctic minke whales caught in 1971–72 and 1972–73.

TABLE 4. Estimation of M of the Antarctic minke whale.

Sex	Range of age	M	Correlation coefficient
♂	15–36	0.122	−0.939
♀	12–42	0.129	−0.970

as constant, at least in the age ranges shown in the table, and values of both sexes are almost the same.

From Ovulation Rate and Corpora Composition

Figure 7 shows the frequency distribution of corpora number in both ovaries of the females caught in the 1971–72 and 1972–73 Antarctic seasons.

A regression line is obtained in the range of corpora numbers from two to 30. The gradient is calculated to be 0.107 with a correlation coefficient of −0.9726. However, it does not represent the figure of M, and means natural mortality per one corpus in both ovaries. We estimated the annual ovulation rate (above) to be 0.866. Then, we can calculate the value of M from the annual ovulation rate and the gradient of the regression line of corpora composition. It is 0.124, and it is the value of M in the female.

We estimate the value of M in the female from two independent approaches. Both figures are very similar to each other, and the average will be the most reasonable. It is 0.127, and we regard it as M of the female Antarctic minke whale in the virginal population level. In the previous paper by Ohsumi et al. (1970), a preliminary estimate of M was 0.104, a combined figure for both sexes. However, it must be corrected on the basis of the new data above.

Natural Mortality in Sexually Immature Stage

Since the age at sexual maturity is 6 yr in the female, and M was calculated by the use of the sample 12 yr and over in the case of females, the value of M obtained represents that in the sexually mature stage. The natural mortality coefficient, in the immature stage, M′, will be different from M.

However, we cannot estimate M′ directly from age composition, for the age composition does not represent the population throughout all ages.

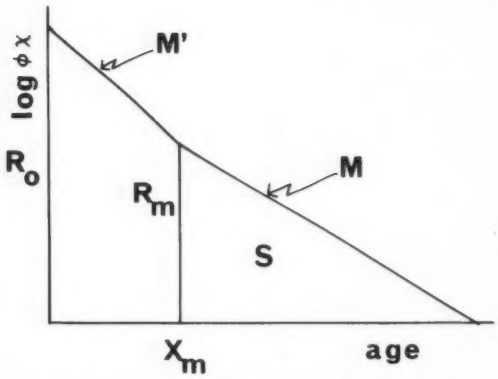

FIG. 8. A population model of the virginal population level.

A simple population model is introduced for the estimation of M′ as shown in Fig. 8.

The following equations are completed in the model:

$$R_o = S \cdot p \cdot l \cdot h \quad (1)$$

$$R_m = R_o \cdot e^{-x_m M'} \quad (2)$$

$$S = R_m/(1 - e^{-M}) \quad (3)$$

$$1 - e^{-M} = p \cdot l \cdot h \cdot e^{-x_m M'} \quad (4)$$

Now, the values of p (= 0.85), l (= 1.007), h (= 0.5), M (= 0.127), and x_m (= 6) were already estimated in the previous sections. Then, M′ is calculated from equation (4) to be 0.213. It is notable that this M′ is the average of M′ in immature stages, and it is higher in younger ages, and lower in older ages.

Recruitment

AGE AT RECRUITMENT

Due to the lack of a legal size limit in the Antarctic minke whale, the age at recruitment, x_r, will vary with differences in age composition on the different whaling grounds, for there is some age segregation in the distribution of the Antarctic minke whale.

If the age compositions that were obtained from whales caught in 1971–72 and 1972–73 are regarded as representative of the population on the whaling ground (even though whalers are apt to take larger whales) the ages at recruitment can be estimated by means of the following equations:

$$R_x = \phi_x/\phi_{x-1}e^{-x} \quad (5)$$

$$x_r = \Sigma x \cdot R_x/\Sigma_x \quad (6)$$

ϕ_x is obtained from the frequency distribution of age. In this paper Z = M or M′, and this is 0.213 until 6 yr, and 0.127 after 6 yr, as calculated above.

The estimated ages at recruitment, calculated by means of above equations and data, are 5.9 and 6.9 yr in males and females, respectively. Thus, we conclude that the age at recruitment of the minke whale in the Antarctic whaling ground is about 6 yr, that is, almost the same as the age at sexual maturity.

RATE OF RECRUITMENT IN VIRGINAL POPULATION LEVEL

From age composition we can estimate the recruitment rate, r, by means of the following equation:

$$r = \Sigma R_x/\Sigma\phi_x \quad (7)$$

The result is 0.112 in the case of females.

On the other hand, r is also calculated from the population model as shown in Fig. 8. If $x_r = x_m$ as estimated in above section,

$$r = R_m/S \quad (8)$$

From equations (1) and (2),

$$r = p \cdot l \cdot h \cdot e^{-x_m M'} \quad (9)$$

When the biological parameters, as shown in previous sections, are put into the equation (9), r is calculated to be 0.119. This figure coincides very closely with the figure that was obtained from the age composition of females.

It must be remembered that this figure of r is in the virginal population level, and r increases with the decline of population level.

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New Records of the Pygmy Right Whale (*Caperea marginata*) from South Africa, with Comments on Distribution, Migration, Appearance, and Behavior[1]

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Ross, G. J. B., P. B. Best, and B. G. Donnelly. 1975. New records of the pygmy right whale (*Caperea marginata*) from South Africa, with comments on distribution, migration, appearance, and behavior. J. Fish. Res. Board Can. 32: 1005–1017.

Nine South African records of *Caperea marginata* are strongly seasonal, all occurring in the period December–February. The world distribution is summarized, based on a total of 71 individuals. Migration may include dispersal of juveniles into inshore waters in spring and summer. The first underwater photographs of this species are presented, and from them and other records, the body shape and external pigmentation are described. Behavior in the wild is unspectacular, probably making the species relatively inconspicuous at sea.

Ross, G. J. B., P. B. Best, and B. G. Donnelly. 1975. New records of the pygmy right whale (*Caperea marginata*) from South Africa, with comments on distribution, migration, appearance, and behavior. J. Fish. Res. Board Can. 32: 1005–1017.

Neuf signalements de *Caperea marginata* sont fortement saisonniers, tous se produisant dans la période de décembre à février. Nous donnons un résumé, fondé sur 71 individus, de la répartition mondiale de l'espèce. La migration peut inclure une dispersion des jeunes vers le littoral au printemps et en été. Nous présentons les premières photographies sous-marines de l'espèce et, à partir de celles-ci ainsi que d'autres mentions, décrivons la forme du corps et la pigmentation externe. Le comportement de cette baleine à l'état sauvage n'est pas spectaculaire, ce qui probablement la met relativement peu en évidence en mer.

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Since Dr J. E. Gray's description of the pygmy right whale (*Caperea marginata*) in 1846, data on some 40 specimens have been reported in the literature, from animals captured or stranded in widely separated localities in the Southern Hemisphere. In most cases, however, the information available from these records is scanty, so that while the osteology (Beddard 1901; Oliver 1922; Hale 1964) and the external appearance (Davies and Guiler 1957; Ivashin et al. 1972) are relatively well documented, almost nothing is known of the biology and behavior of this species. In their review of the records of pygmy right whales, Davies and Guiler (1957) included the three South African specimens known at that time. Subsequently these whales have been recorded on this coast on at least six occasions, four of which involved sightings of live animals; this paper reviews the South African records and discusses them in relation to our present knowledge of the distribution, appearance, and behavior of this species.

South African Records

There have now been a total of nine, possibly 10 occasions on which *Caperea* has been recorded from South Africa (Table 1). Although four of these records involved sightings, the identification of the species could be determined

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TABLE 1. South African records of the pygmy right whale, *Caperea marginata*.

Date	Locality	Remarks
Jan. 12, 1917	Simonstown, False Bay	3.39-m[a] male, harpooned by G. Cotton. Skeleton in South African Museum (cat. no. 14407).
Jan. 23, 1937	Gordons Bay, False Bay	Animal stranded then burned by local council (Barnard 1954).
Jan. 15, 1957	Fish Hoek, False Bay	Animal caught by net from the beach and killed by fishermen (Fig. 6). Skull collected (SAM 19944), CBL 790 mm.
Feb. 26–27, 1963	Fish Hoek, False Bay	2.90-m animal (sex unknown) caught by net fishermen from the beach — examined and released by C. K. Tayler.
Feb. 1–23, 1965	Fish Hoek, False Bay	Two live individuals observed frequently (by P.B.B.) during this period. One caught by net from the beach — examined (not by P.B.B.) and released.
Dec. 18, 1965	Port Elizabeth, Algoa Bay	2.98-m animal (sex unknown) found dead in harbor by Mr Lubbe (Fig. 7). Skeleton in Port Elizabeth Museum (cat. no. 1514/10).
Dec. 1967	Plettenberg Bay	Live animal photographed and filmed underwater by T. Dicks (Fig. 1–5).
Dec. 1967	Mossel Bay	Baleen plate from stranded animal in possession of Mr. Cairncross, Victoria Bay, George.
Jan. 28, 1968–Feb. 3, 1968	Fish Hoek, False Bay	Live animal seen frequently during this period (Fig. 8).
(An animal corresponding in description to *Caperea* was taken during the 1969 whaling season off Durban in error, while running with a minke whale. No further data are available other than the probable month of capture, July or August — Mr D. Miles, Union Whaling Co., personal communication.)		

[a]Not 3.35 m as recorded by Davies and Guiler (1957).

in two instances from examination of a temporarily restrained animal by a reliable observer, and in the other two instances from photographs taken above or below water.

The known range of the species around the South African coast has now been extended from False Bay east as far as Algoa Bay, with intermediate records from Mossel Bay and Plettenberg Bay. The unconfirmed record from Durban would extend the range even farther up the east coast.

The seasonality of the South African records is most marked, only the animal reported from Durban occurring outside the period December to February.

Distribution

The pygmy right whale is restricted to the Southern Hemisphere, and is circumpolar in distribution. The regional distribution of records is as follows: South Australia, 7 (Hale 1964; Aitken 1971); Victoria, 1 (Wakefield 1967); Western Australia, 1 (Davies and Guiler 1957); Tasmania, 14 (Davies and Guiler 1957; Guiler 1961; Davies undated); New Zealand, 13 (Davies and Guiler 1957; Gaskin 1968); South Africa, 9 (present paper); South Atlantic, 3 (Budylenko et al. 1973; Ivashin et al. 1972); Falkland Islands, 1 (Hamilton 1952); Crozet Islands area of the Antarctic, 1 (Ivashin et al. 1972). These involve a total of about 71 individuals. Cabrera and Yepes (1940) record a specimen from the province of Buenos Aires in Argentina and state that pygmy right whales are occasionally recorded on the Chilean coast. Aguayo (1974) has been unable to trace any authentic Chilean records.

Wilson (1907) reported numerous sightings of pygmy right whales in the Ross Sea, but Lillie

TABLE 2. Records of pygmy right whales in relation to latitude and month.

Latitude	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	V
South Atlantic (32–35°S)						2	1					
South Africa (34–35°S)							3	3	3			
South Australia (35–36°S)			1	1	2		1					
Tasmania (40–43°S)	4	1		1	1	1	1	1	1			
Crozet Is. (46–47°S)									1			
New Zealand (47°S)[a]					1			1			1	
Total	4	1	1	2	4	3	6	5	5		1	

[a]The three records for which the month of occurrence is known are all from Stewart Island.

(1915) has refuted these records on the grounds that they were probably minke whales. Ivashin et al. (1972) have recorded a sighting of three pygmy right whales at a latitude of apparently 46–47°S, but the most southerly specimen recorded is from the Falkland Islands (Hamilton 1952), which though lying in 52°S are still north of the Antarctic Convergence. There is therefore no confirmed record of pygmy right whales in strictly antarctic waters, and as yet little evidence to suggest that they occur there at times.

The northern limit of distribution is not as conveniently delineated by a recognizable zoogeographical boundary as is the southern limit. Latitudinally, the most northern records lie at 31°S (western Australia) and 32–56°S (South Atlantic), unless one considers the Durban "record," which would be at a latitude of about 30°S. Davies and Guiler (1957) noted that the summer isotherm for 20 C conveniently marked the northern limit of distribution for almost all the records of pygmy right whales, though they did not claim that temperature acted directly as a limiting factor. Subsequent records have also occurred near or south of this isotherm.

Too little is known of factors influencing the distribution of cetaceans to make more than tentative suggestions concerning them. The availability of suitable food is almost certainly one of the most important factors. In the case of pygmy right whales of which the food, as far as is known, consists of copepods (Ivashin et al. 1972), it could be expected that the distribution pattern would be similar to that of the plankton where it occurs in exploitable quantities. The distribution of pygmy right whales south of 40°S, in fact, resembles that of southern right whales and sei whales in that the bulk of the population appears to stay north of the Antarctic Convergence in summer. Both right and sei whales are considered primarily copepod-eaters, so that this distribution may reflect the relative abundance of suitable food. North of the Antarctic Convergence the productivity of the open ocean drops markedly towards the tropics, possibly to the level where the quantity of plankton is insufficient or too patchy to support even the smallest baleen whale.

Very little is known of the migrations of the pygmy right whale. Davies and Guiler (1957) maintained that a seasonal north–south migration as observed in other baleen whales does not occur in this species, on the grounds that strandings occurred in the spring and early summer in the northern part of the species' range. They suggested that pygmy right whales are present off southern Australia and New Zealand throughout the year, but move inshore during the spring and early summer, possibly associated with some phase of the reproductive cycle such as mating. The addition of several new records since their paper prompted a review of the problem, and each record for which the month of occurrence is known is presented in Table 2. The New Zealand records occurred in spring and summer, but few of the records (three out of 13) have monthly data, and the spread of occurrence is possibly much wider than suggested by these three records. The Tasmanian animals were recorded in nearly all months of the year, suggesting that whales are present in these latitudes throughout the year. In South Australian and South African waters their occurrence is seasonal in the months of August–December and December–February, respectively. Overall, however, there is a great preponderance (71.9%) of spring and summer records, suggesting a greater susceptibility to stranding or being seen from the shore at this time of year.

A large proportion of the records presented in

TABLE 3. External measurements of *Caperea marginata*. Total length is given in centimeters. Other measurements are expressed as percentage of total length.

Source Sex	Ivashin et al. (1972) ♀	Davies and Guiler (1957) ♀	Guiler (1961) ♀	Hale (1931) ♂	Hale (1964) ♂	Hale (1931) ♂	Present paper (Simonstown 1917) ♂	Ivashin et al. (1972) ♂	Present paper (Port Elizabeth 1965) ?
Total length	621	640[a]	637	277	305	330	339	547	298
Tip of snout to eye	21.4	—	15.1	—	22.5	21.5	—	21.0	23.0
Length of gape	23.2	—	—	—	20.0	20.0	—	23.8	—
Tip of snout to blowholes	13.9	13.1	11.9	—	—	—	—	14.4	14.5
Tip of snout to anterior insertion of flipper	31.9	—	—	—	35.1	—	—	33.1	34.1
Tip of snout to anterior insertion of dorsal fin	67.0	—	—	—	73.1	66.9	—	66.7	67.0
Length of flipper, anterior insertion to tip	13.7	10.3	13.5	—	10.0	10.8	11.2	13.2	11.3
Length of flipper, axilla to tip	10.5	8.8	6.3	—	—	6.9	—	7.9	—
Width of flipper	3.2	—	—	—	—	—	—	3.5	—
Height, dorsal fin	5.0	3.9	4.7	—	5.1	3.8	—	4.8	—
Length, dorsal fin base	6.0	—	—	—	5.1	—	—	8.6	—
Width of flukes	—	28.3	—	19.7	20.0	—	—	31.4	—
Width of single fluke	16.1	—	14.3	—	—	—	10.1	16.5	11.9
Length, fluke notch to dorsal fin	32.4	35.8	26.2	—	—	—	30.0	26.5	—

[a]Measured along the curve of the back.

Table 2 for South Australia and South Africa for which total lengths are known, or have been estimated from skull length, is of juvenile animals. Three of the five South Australian animals had lengths of 2.77 m (September), 3.30 m (October), and 3.05 m (December) (Davies and Guiler 1957). All three South African animals of known length were juveniles with lengths of 2.98 m (December), 3.39 m (January), and 2.90 m (February), while a fourth animal was considered to be a subadult (December). The only other juvenile for which the month of occurrence is known was a Tasmanian record of 3.35 m in length (December). There is little information on the breeding biology of pygmy right whales. Two pregnant females have been examined with fetuses of 42 cm and 24 cm, caught in November and December, respectively (Budylenko et al. 1973; Ivashin et al. 1972), and a fetus 60 cm in length was taken from a female stranded in June (Guiler 1961). These fetal lengths suggest an extended mating and calving season of several months (Ivashin et al. 1972). The lengths at birth and at weaning are unknown for this species, but by analogy with other baleen whales it is possible to give estimates of these figures. From values tabled by Bryden (1972) of lengths at birth and weaning for eight species of baleen whales, including birth lengths of two balaenids, the lengths at birth and weaning can be calculated as 26–33% and 52–60%, respectively, of the physically mature female. The recorded lengths of the four largest female pygmy right whales are 6.4 m (Davies and Guiler 1957), 6.37 m (Guiler 1961), and 6.21 m and 6.35 m (Budylenko et al. 1973; Ivashin et al. 1972), with an average length of 6.32 m. The theoretical lengths of pygmy right whales at birth and weaning would then be 1.6–2.2 m and 3.2–3.8 m with averages of 1.9 and 3.5 m.

A comparison of these lengths with those of recorded juveniles clearly shows that the latter are not newborn animals and that the larger juveniles are probably close to if not already weaned. Such juveniles have been recorded in October, December, and January. Assuming a lactation period of some 5 or 6 mo these animals would have been born in the preceding autumn or winter. Hence, the postulated inshore movement in spring and summer does not seem to be linked to the season of birth, or (if pregnancy should last about a year as in most other cetaceans) to the breeding season, although Hale (1964) recorded a pygmy right whale with calf in July in Port Lincoln Bay, South Australia, a few weeks prior to the August stranding of an adult female in the bay, and mentioned that it was not uncommon for pygmy right whales to be reported in this bay in winter.

In fact, nearly all of the specimens seen or caught close inshore (as opposed to those that have stranded) have apparently been juveniles or subadults, and the seven presumptive juveniles for which accurate sizes are known (see above) were all recorded in the months from September to February. The appearance of *Caperea* in inshore waters in spring and summer might therefore represent an influx of juveniles, possibly as part of a more general dispersal of animals after weaning.

As such, it could be largely unrelated to seasonal migrations of adults, although considerably more data will be required before the timing and pattern of movements in this species become clear.

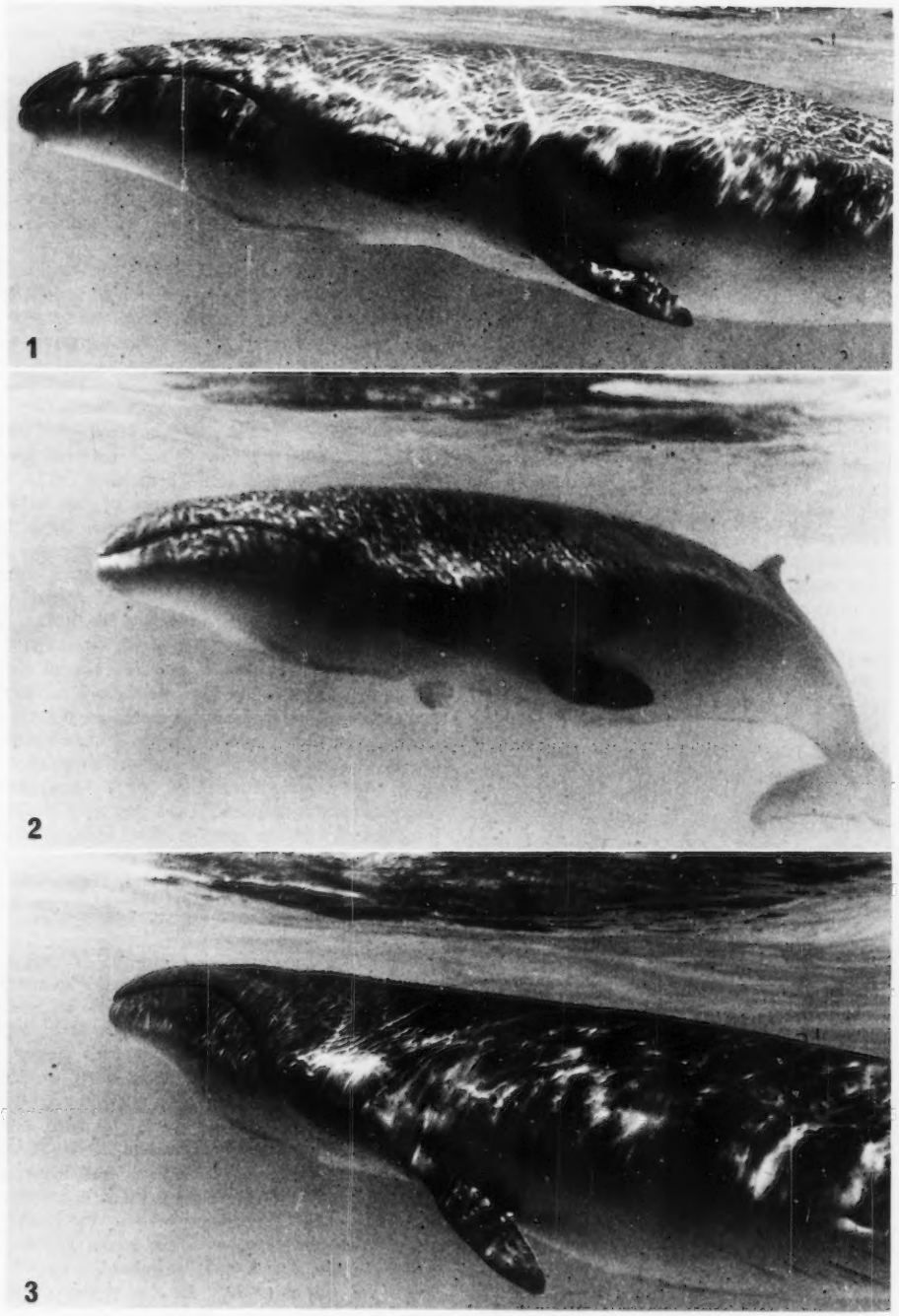
External Appearance

Descriptions of the external form of *Caperea* have been given by Hale (1931) and Davies and Guiler (1957), and Ivashin et al. (1972) have described the external characters of two captured adults in detail. These descriptions have been based on dead, and sometimes decomposing specimens in which some postmortem changes are highly probable but unknown in extent.

It is now possible to illustrate the living, submerged animal in a unique series of underwater photographs (Fig. 1–5) as well as a clip of 16 mm movie film taken by the late Mr T. Dicks at Plettenberg Bay. In addition, notes on the appearance of the live, restrained animal were taken by Mr C. K. Tayler in 1963, and the original notes on the 1917 animal made by Mr J. Drury of the South African Museum have become available. Photographs of the freshly killed animal at Fish Hoek in 1957 (Fig. 6) and of the stranded Port Elizabeth specimen (Fig. 7) have also enabled features of the species' external appearance to be studied.

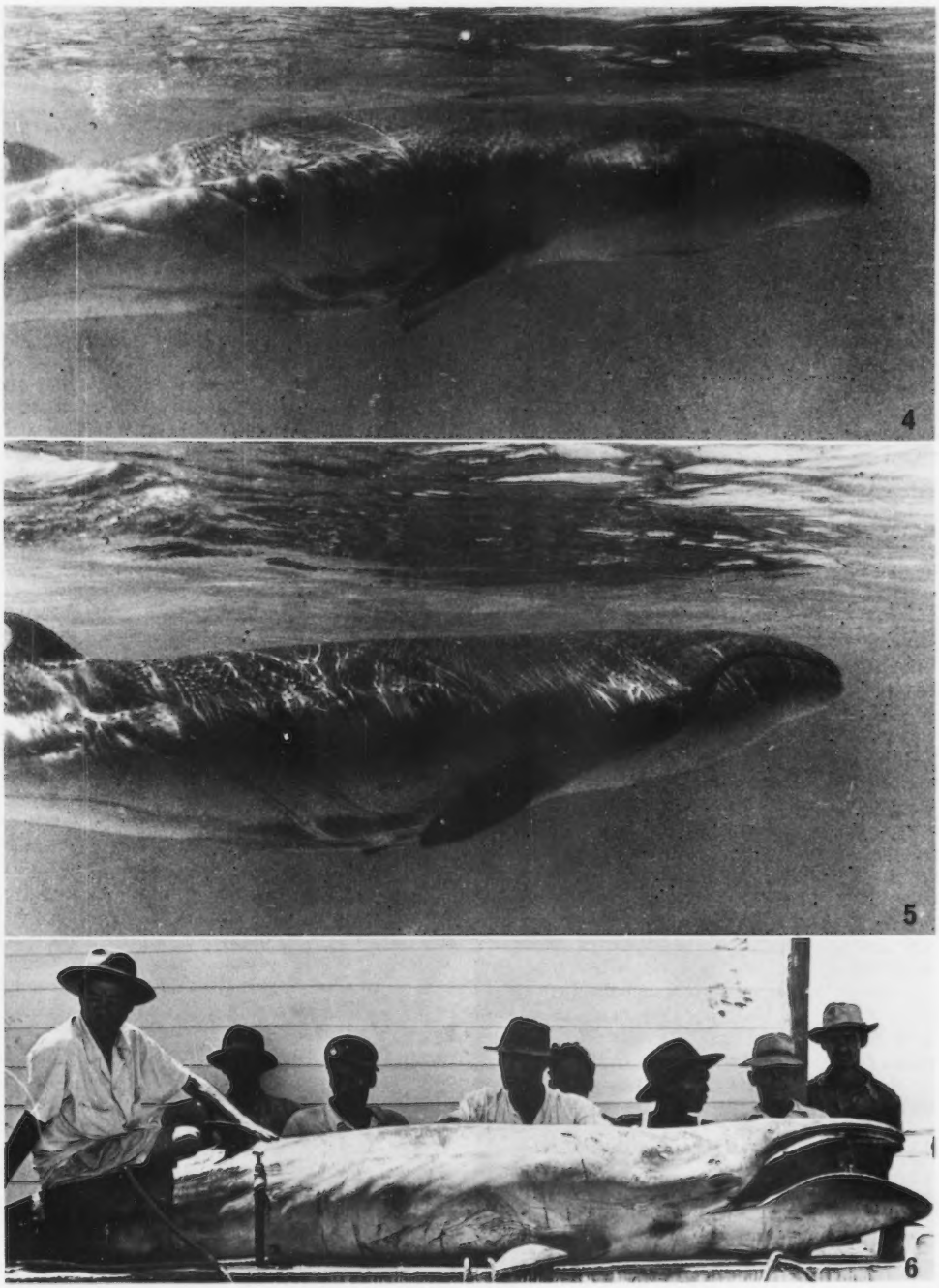
Body shape — The distinguishing characters of the species as described by previous authors are clearly shown in the photographs, namely, bowed lower jaws, and an arched, tapered upper jaw with the line of the mouth extending posteriorly below the eye, narrow flippers slightly rounded at the tip, a small triangular dorsal fin with a falciform posterior margin more than two thirds of the body length from the snout, and broad, full tail flukes with a well-formed median notch.

Several other features described by Ivashin et al. (1972) are clear in these photographs. The lower jaw projects slightly beyond the upper jaw, there are no callosities on the upper or lower jaws as in *Eubalaena*, and the upper margins of the lower jaw are not scalloped. A concavity on



FIGURES 1–3.

FIGS. 1–3. Pygmy right whale, *Caperea marginata*, at Plettenberg Bay in December 1967.



FIGURES 4–6.

FIGS. 4–5. Pygmy right whale at Plettenberg Bay, South Africa, December 1967. FIG. 6. Pygmy right whale caught at Fish Hoek by net from beach and killed by fishermen on Jan. 15, 1967.

either side of the midrostral ridge continues posteriorly into a broad depression above the eye. The upper and lower eye folds are shown clearly. Though the neck is not demarcated dorsally, this feature is apparent in the lateral and ventral constriction of the body between the eye and the flipper. In dorsal view the head narrows abruptly anterior to the eyes, and the rostrum tapers gradually to a rounded point (Fig. 7b: the blowholes converge from 7.5 cm apart posteriorly to 2 cm anteriorly). A shallow groove is present on the ventrolateral margin of the rostrum (Fig. 7d and c) which is presumed to correspond with the dorsal margin of the lower jaw. Other features of interest are the strongly ridged palate and the tongue which is fimbriated at the tip (Fig. 7c).

In the photographs shown by Hale (1964), Ivashin et al. (1972), and Davies and Guiler (1957) and the last authors' outline drawing, the ventral outline of the anterior half of the body is distorted, giving a rounded, deep-bodied appearance to the animal. This distortion may be due in part to the effects of decomposition, and in the case of the Russian-caught specimens, the effect of inflation with an air hose; much of it though is the effect of postmortem relaxation and distension of the throat region, similar to that described in balaenopterids (Williamson 1972). The true shape of this region in the living animal is more streamlined (Fig. 1–5), and shows a feature previously undescribed in this species. In profile, the ventral outline of the throat is concave anteriorly becoming convex posteriorly. This convexity appears to be formed by a distinct ridge on each lower jaw extending from the midlength of the gape to the level of the eye, and corresponding in position with the ventral margin of the posterior half of each mandible. The appearance of these ridges is clearer in Fig. 7d which shows the throat region of the Port Elizabeth juvenile. In this animal there are two clearly defined grooves bounded laterally by these mandibular ridges and medially by a third, median ridge. Though the two mandibular ridges are clearly visible in parts of the movie film of the Plettenberg Bay animal, the median ridge and the two grooves cannot be seen, and their exact nature in the living animal is uncertain. If their presence should be confirmed, the interesting possibility arises that these grooves might represent a simple form of the throat grooves found in balaenopterids and the gray whale.

The extensive rib cage characteristic of this species can be seen in the Fish Hoek specimen (Fig. 6). The last rib is apparent as a bulge in the body wall below the dorsal fin.

Three long, rake-like scars are visible on the right flank and belly of the Plettenberg Bay animal (Fig. 4 and 5), while Fig. 1 and 3 show a series of six radiating scars on the left lower flank. The origin of these scars is unknown; though the position and similarity of those on the right side suggest they were made simultaneously, it is difficult to envisage an animate or inanimate object capable of causing such divergent wounds.

The length of the latter animal is not known with any certainty. Attempts to find proportional measurements which might have been of value in distinguishing young animals from adults were not successful (Table 3), excepting the apparent increase in fluke width with age, which is unfortunately inapplicable in this case. Davies and Guiler (1957) noted that the arching of the jaws appears to increase with age. The appearance of the young animal illustrated by Hale (1964) and the adults shown by Ivashin et al. (1972) support this observation. A comparison of the Plettenberg Bay animal with the animals figured by these authors, by Hale (1931), and with those of known length in the present paper suggests that its jaws are intermediate in curvature between an immature 3–3.5 m in length and an adult. It is probably, therefore, a subadult animal.

Color pattern — Prior to the adult specimens examined by Ivashin et al. (1972), descriptions of color pattern in *Caperea* had been based on dead, and probably decomposing animals, for which the times between death and examination are not known. As cetaceans darken rapidly in color after death, particularly when exposed to the sun, it is uncertain whether the general description of "black above, paler below or black all over" by several authors (see Davies and Guiler 1957) are correct or due to postmortem effects.

The description of the juvenile harpooned at Simonstown in 1917, for which Barnard (1954) described the color pattern as "black above, dirty white below; baleen yellowish-white, outer edges black," is clearly based on notes on the specimen in the South African Museum files taken by Mr J. Drury, who added further that the inside of the mouth was creamy white, but dark on the outside edges. Davies and Guiler (1957) described the white color of the mouth cavity and tongue of *Caperea*, together with a white band "along the upper jaw above the baleen." This seems to represent the color of the baleen gum, which is usually much darker in other baleen whale species and in balaenopterids is usually covered externally by the upper lip. This feature has been noted subsequently by Hale (1964), Ivashin et al. (1972), and in the present paper (Fig. 6), and exposure of the baleen gum to this extent is possibly characteristic of the species.

The South African records include two animals

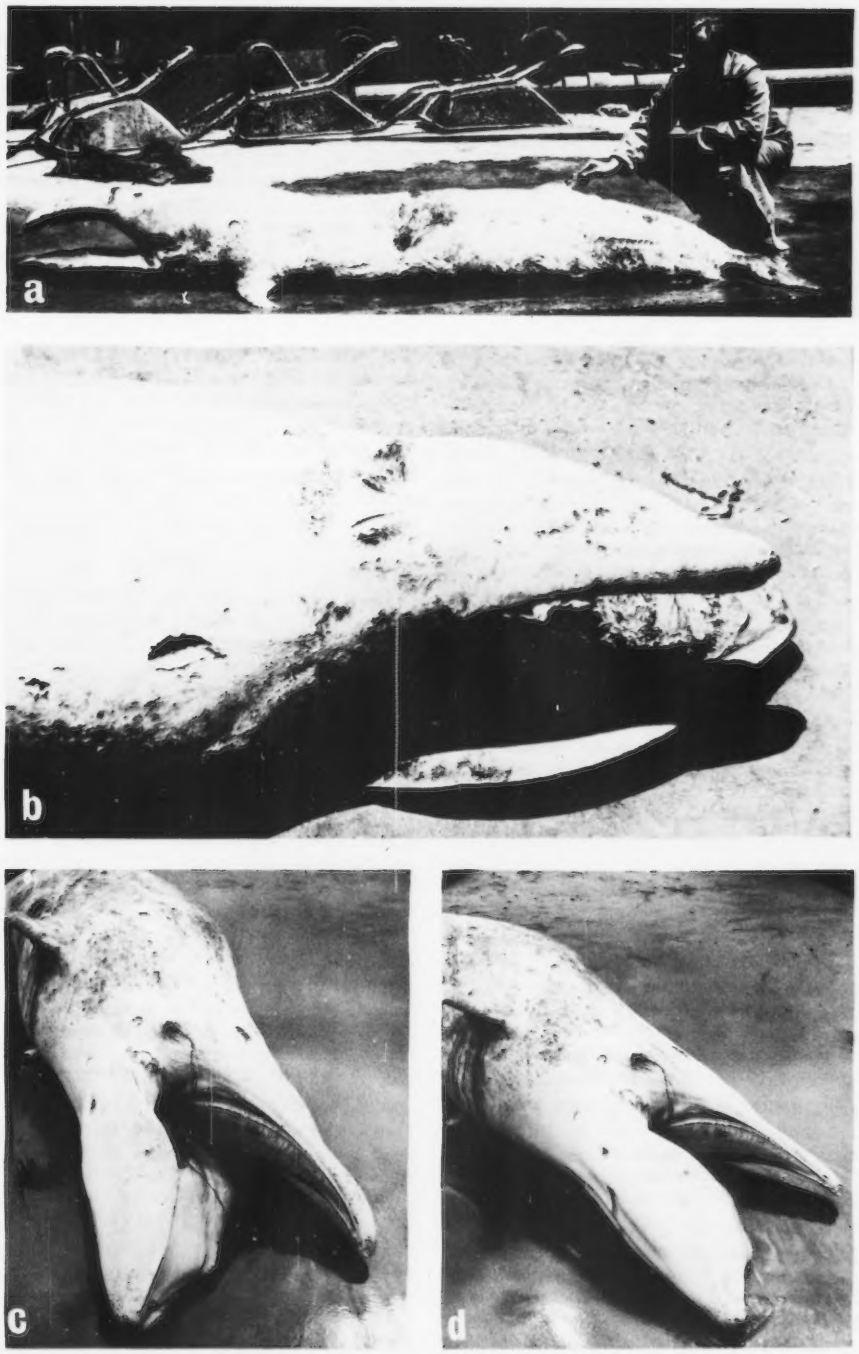


FIG. 7. Pygmy right whale 2.98 m long, stranded specimen found dead in harbor at Port Elizabeth, Algoa Bay.

observed or photographed alive, and a third photographed prior to dismemberment by the fishermen who caught it; collectively, they provide information on the true color pattern, at least in young pygmy right whales.

The actual color tones of the Plettenberg Bay animal are uncertain owing to the effects of light on color when viewed under water, though the pattern of pigmentation is shown quite clearly. The entire dorsal surface appears dark grey or black in the black and white photographs of this animal, but in the color movie film it is grey. The dark dorsal region merges midlaterally into the paler ventral surface. The upper half and tip of the lower jaws are dark grey and a dark band is present between the eye and the point of insertion of the flipper, where it is quite sharply demarcated from the very dark outer surface of the flipper. The ventral surface of the animal is pale whitish in color except for two dark grey streaks on the underside of the lower jaws in positions corresponding to the posterior half of each mandible, and a midventral greyish streak between and posterior to the flippers. These streaks are not very clear in Fig. 1–5, but show fairly clearly in the movie film. The inner surface of the flipper is unfortunately not shown in the black and white photographs and is indistinct in the movie film. The ventral surface of the tail flukes is pale grey with a darker margin (Fig. 2).

Mr C. K. Tayler noted that the color of the live animal examined at Fish Hoek in 1963 was "grey over the dorsal and lateral surfaces of the whole body, including the upper side of the flippers, merging to silvery white ventrally. The baleen was ivory in colour." The apparent absence of the dark outer margin of the baleen may be due to an oversight on the part of the observer.

The color pattern of the 1957 Fish Hoek juvenile as shown in Fig. 6 is somewhat obscured by highlighting. However, in the shadow cast on the caudal region, the dorsal surface appears darker than the ventral surface. The upper half of the lower jaw is darker than the lower half, and the outer surface of the flipper is dark and distinctly demarcated from the body color at its base.

The pattern of coloration of the adult male and female described by Ivashin et al. (1972) was similar to that observed in South African animals. These authors noted that the upper half of the jaw was darker than the lower portion, and that the outer surfaces of the flippers were black and demarcated from the lighter-colored body at their insertion. However, the color of both adults was given as entirely black dorsally, merging laterally into a light grey ventrally in the female and a darker grey in the male. As the time elapsed between capture and examination on board the factory ship is unknown, it is possible that some postmortem darkening had occurred, though such changes were probably minimal if the animals were examined shortly after being hauled from the water. If the adult pygmy right whale is as darkly pigmented as described, the evidence from the more lightly colored, young animals from South Africa suggests that these whales become progressively darker with age.

The skin of the juvenile stranded at Port Elizabeth was too abraded over most of the body to show more than an overall impression of extreme paleness (Fig. 7). On the head the skin was more intact, however, and was uniformly creamy white. In view of the possibility of ontogenetic darkening of animals, this animal might be merely an extremely pale example of a juvenile. However, the uniformity of coloration on dorsal and ventral surfaces suggests that it was albinistic.

Behavior

It is apparent from the capture, sighting, and stranding records that pygmy right whales are frequently found in sheltered, shallow bays when they are encountered inshore. All the known South Australian records have occurred in bays with shoaling waters with exposed areas at low tide (Aitken 1971), while Hamilton (1952) refers to Byron Sound, the locality of the Falkland Island specimen, as a "sort of trap" of narrow and shoaling waters. Ralph Bay, Tasmania, where Davies and Guiler (1957) examined their adult female, is a very shallow bay. All nine South African records are from large bays along the south and southeastern coast. Further, several of these records refer to animals captured or sighted in bays, suggesting that their occurrence in such localities is normal rather than the actions of sick or dying animals seeking shelter prior to stranding. In view of its occurrence at times in sheltered waters, it is surprising that there are so few sight records inshore, and it is only recently that the species has been encountered in the open ocean (Ivashin et al. 1972). Davies and Guiler (1957) have suggested that this whale spends long periods underwater, though not necessarily diving to great depths. Ivashin et al. (1972), however, reported that the animals they observed did not dive to depths of more than 2–3 m, staying underwater for 3–4 min. In addition, the blow on surfacing was small and often inconspicuous, while the time spent on the surface was not longer than 4–5 s. These authors found that the heart and lungs of their specimens were relatively small, suggesting

that it was improbable that the species was a prolonged diver.

Observations made on live animals in False Bay by one of us (P.B.B.) in 1965 and by Mr Tayler in 1963 agree generally with those of Ivashin et al. (1972). On no occasion did any of these animals display the conspicuous behavior typical of southern right whales when seen inshore, namely lifting the tail flukes clear of the water, rolling onto their back or side, or leaping clear of the water. The respiratory rhythm appeared to be fairly regular, the intervals between five successive blows being recorded (by P.B.B.) as from 40 to 55 s with an average of 49 s: Tayler recorded the average as 60 s. The blow is small and hardly distinguishable. When at the surface the animals often failed to expose the dorsal fin, but sometimes on first breaking the surface they appeared to "throw" the snout out of the water, exposing the end of the chin (Fig. 8). At such times a flash of white was often seen, as described by Ivashin et al. (1972), possibly denoting the tongue or the lining of the mouth which must have been slightly open. Generally the whales swam very slowly, estimated at 4 knots by Tayler.

This unspectacular behavior tends to make the species relatively inconspicuous at sea, and this probably accounts for the rarity of sightings, rather than the prolonged submergences proposed by Davies and Guiler (1957). In addition, many sightings at sea have probably been listed as minke whales, for as Ivashin et al. (1972) have pointed out, the two species are similar in silhouette when seen from a distance of only 100 m. The possible association between pygmy right whales and minke whales, as is suggested by the unconfirmed record off Durban in 1969, could also lead to sightings of pygmy right whales being misreported. These whales have been encountered previously with dolphins, sei whales, and pilot whales on separate occasions (Davies and Guiler 1957; Ivashin et al. 1972).

The 16 mm movie film taken of the Plettenberg Bay animal provides a unique opportunity to observe some aspects of the swimming behavior in this species. The film was taken in water about 6 m in depth over a sandy bottom, with the visibility range estimated at approximately 15 m. It contains a number of sequences of the whale, including fast, moderate, and slow swimming, rapid starts and turns and breaking the surface, possibly for air. The most striking feature of the swimming behavior was the extensive flexing of the animal's entire body. A single complete cycle of the flukes is shown in Fig. 9, traced from successive frames in a sequence where the whale had leveled out after surfacing and was swimming at a moderate speed.

FIG. 8. Pygmy right whale observed in Fish Hoek Bay, January–February 1968.

This series of outlines shows that waves of motion pass from the head to the flukes, apparently increasing in amplitude as they do so. This observation is interesting in the light of Wu's (1961, in Lang 1966) theory that swimming is most efficient when wave amplitude increases towards the tail, based on his observations of a moving flexible plate. The undulatory motion is seen in fast and slow swimming as well. This whale appeared capable of extremely rapid acceleration. In a number of sequences in the first part of the film, the whale seems to have been scared, possibly by the close approach of the divers, and suddenly erupted into fast swimming. In one such sequence, the first quarter of the cycle, from a level stationary position to the end of the downstroke, occupied four frames, or 0.25 s, while the entire first cycle occupied 12 frames, or 0.75 s, by which time the animal was already moving with some speed. The degree of flexing of the body appeared to be similar in fast and moderate swimming, but was less extensive in slow swimming.

The flippers were held close to the body during fast and moderate swimming, but were extended ventrally and laterally during slow swimming, turning, and while breaking the surface. They were held out such that they subtended an angle of about 120° between them. After breaking the surface they were folded back only when the animal had leveled out some 2 m below the surface. The sequence shown in Fig. 9 shows the moment and manner of flipper retraction.

The only estimates of the swimming speed of pygmy right whales are those of Tayler mentioned earlier and of Ivashin et al. (1972), ranging from 3 to 5 knots. In the final sequence of this film, the whale turned away from the camera and swam directly away at moderate speed until it disappeared. From the turn to the time of disappearance took about 100 frames or approximately 6 s, and in this time the whale moved about 15 m (the estimated limit to visibility) less the distance between the whale and the camera,

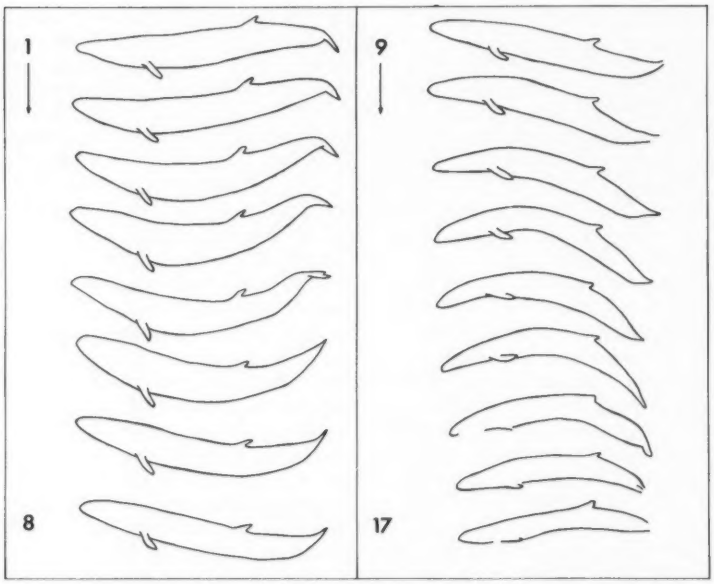


FIG. 9. Pygmy right whale showing a single complete cycle of the flukes, from the 16 mm movie film at Plettenberg Bay, December 1967.

possibly 5 m. These figures give an estimated speed of 1.7 m/s, or 3.2 knots, which is comparable to previous estimates.

Acknowledgments

We would like to thank Mrs F. Hayes for permission to examine and use the photographs and movie film taken by the late Mr T. Dicks. We also wish to thank Miss R. M. Tietz, Mr C. K. Tayler, Mr B. Cairncross, and Mr D. Miles for their information and photographs concerning pygmy right whale records.

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Autumn Stranding of a Northern Bottlenose Whale (*Hyperoodon ampullatus*) in the Bay of Fundy, Nova Scotia[1]

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MITCHELL, E., AND V. M. KOZICKI. 1975. Autumn stranding of a Northern Bottlenose Whale (*Hyperoodon ampullatus*) in the Bay of Fundy, Nova Scotia. J. Fish. Res. Board Can. 32: 1019–1040.

A 615-cm male northern bottlenose whale (*Hyperoodon ampullatus*) stranded in Cobequid Bay, Bay of Fundy, in early October 1969. The skull, mandible, tympano-periotics, and teeth are described and illustrated. Five growth layers in the lower teeth place the animal below a growth curve based on samples from the Labrador Sea taken in May and June. A summary of nine other North American occurrences of 12 individuals, mainly south of Sable Island, indicates a winter migration to waters offshore of Massachusetts and Rhode Island.

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Un hypéroodon (*Hyperoodon ampullatus*) mâle de 615 cm s'est échoué dans la baie Cobequid, baie de Fundy, au début d'octobre 1969. Nous en décrivons, avec illustrations, le crâne, la mandibule, les os tympano-périotiques et les dents. Cinq couches de croissance dans les dents inférieures placent cette baleine au-dessous d'une courbe de croissance fondée sur des échantillons de la mer du Labrador capturés en mai et juin. Un résumé de neuf autres occurrences de 12 individus en Amérique du Nord, en majorité au sud de l'île de Sable, indique une migration hivernale vers les eaux du large du Massachusetts et du Rhode Island.

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WE learned from an article and photograph in the Halifax *Chronicle Herald* (Vol. 21, No. 250, October 18, 1969) of the stranding of an intact beaked whale in Hants County, N.S. The stranding occurred in the vicinity of Noel Head, in the uppermost reaches of the Bay of Fundy, in Cobequid Bay off Minas Basin (45°19.5′N, 63°42.0′W). The whale had been discovered by Mr M. Densmore on October 9, 1969. Kozicki inspected the animal on October 19, 1969, and found an intact but bloated carcass of a male North Atlantic bottlenose whale, *Hyperoodon ampullatus*. At high tide the whale was almost afloat, but at low tide was stranded on a tidal flat, available for inspection and measurement (Table 1). (The Bay of Fundy is noted for its extreme fluctuations in tidal range.) The skull (Tables 2–4, Fig. 1–6; VMK 4) has been catalogued in the Department of Mammalogy, National Museum of Canada, as N.M.C. 42836. Kozicki was not the first to examine the whale. Many others, including a group from Acadia University in Wolfville, N.S., studied the carcass. One of these parties described the circumstances of the stranding, and mentioned the visit of Kozicki (Case and Densmore 1970).

Case and Densmore (1970) speculated that "it seems unlikely that the live animal would have wandered from its normal habitat." It is unknown what the normal habitat is for this species in autumn on this coast. There has been a fishery for the bottlenose whale in The Gully off Sable Island (Mitchell 1974). The route and timing of migration is largely unknown for this species in the northwest Atlantic, and it is possible that it normally or exceptionally moves into the Bay of Fundy. However, we do not discount the possibility that the carcass washed into the Bay.

The significance of this stranding is twofold. First, the time and site of stranding may be a clue to the autumn movements of this population.

Second, the autumn stranding of a relatively fresh carcass (photograph, Case and Densmore 1970) yields biological material of importance in age determination of bottlenose whales.

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974, subsequently revised.

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TABLE 1. Measurements in centimeters (after Norris 1961) of a male northern bottlenose whale (*Hyperoodon ampullatus*) found stranded in Cobequid Bay, Nova Scotia on October 9, 1969. Proportion expressed in one-thousandths of total length.

	Measurement	Proportion
1. Length, total	615	1.000
2. Length, snout to eye	80	0.130
3. Length, tip of upper jaw to apex of melon	75	0.122
4. Length, snout to mouth crease	42	0.068
7. Center of eye to corner of mouth (direct)	53	0.086
8. Center of eye to center of blowhole (direct)	75	0.122
9. Length, snout to center of blowhole	88	0.143
10. Length, snout to anterior origin of flipper	140	0.228
11. Length, snout to tip of dorsal fin	418	0.680
14. Length, snout to center of anus	400 (?)	0.650
15. Projection of lower jaw beyond upper	4	0.007
17. Blubber thickness, midback ahead of fin	8	0.013
18. Blubber thickness, midside, amidships	6	0.008
21a. Girth at eye	260	0.423
27. Blowhole width	16	0.026
29. Length, flipper (anterior origin to tip)	62	0.101
30. Length, flipper (axilla to tip)	44	0.072
31. Width, flipper (maximum)	19	0.031
32. Height, dorsal fin (fin tip to base)	29	0.047
33. Length, dorsal fin base	53	0.086
34. Width, flukes (tip to tip)	172	0.280
35. Fluke notch to nearest point on leading edge	56	0.091

Description

External Appearance

No observations were made of pigmentation, as the epidermis was peeling. Photographs (Case and Densmore 1970, same photo in *The Chronicle-Herald*; our Fig. 1) show the two prominent ventral throat grooves characteristic of ziphiids. The projection of the lower jaw beyond the upper, shape of the lip crease, and size of the melon are similar to other specimens (e.g. Lubbock 1937, photograph facing p. 90; Harmer 1927, fig. 23) and differ slightly from *H. planifrons* (e.g. Zemskiy and Budylenko 1970, fig. 4–5).

Parasites

Mr P. Arnold observed and collected a sample of sessile barnacles from the right side of the whale, approximately half-way between the dorsal fin and the flukes (Case and Densmore 1970; Fig. 1e). These have been tentatively identified as *Tubicinella* (S. Bleakney, personal communication, March 13, 1975), but this needs confirmation.

This barnacle occurs on some northern and southern hemisphere cetaceans (Pilsbry 1916, p. 281–282). Tomilin (1957, 1967) does not list it for any northern hemisphere odontocete. It apparently occurs on the head of southern right whales (Pilsbry 1916, and references cited), but its occurrence in the North Atlantic was at that time (Pilsbry 1916) based solely upon a right whale stranded on the Faeroe Islands in 1650 (Worm, see Allen 1916, p. 173). The orifice of *Tubicinella* is often covered with cyamids (van Beneden 1876, p. 34), and in Antarctic sei whales they may also serve as a base for attachment of the stalked barnacle *Conchoderma* (Liouville 1913, p. 109). They are apparently parasitic to a degree, as they secrete an enzyme that dissolves skin proteins which they then probably consume (L. Matthews, cited by Tomilin 1967, p. 58).

Skull

The maxillary crests are large. They drop steeply down to the level of the maxillary posteriorly (Fig. 2–4), such that in lateral view the narial aperture is almost visible, and the maxillary is not thickened posteriorly, as in other specimens of *H. ampullatus* (e.g. photographs in Elliot 1901, pl. 4; True 1910, pl. 32; Miller 1923, pl. 7; Turner 1912, frontispiece) and unlike southern bottlenose whale, *Hyperoodon planifrons* (e.g. Flower 1882; Fraser 1945; Tietz 1966). The relative size and prominence of the maxillary crests is a feature enhanced with age (e.g. illustrations in Vrolik 1848; Gray 1882; van Beneden and Gervais 1868–80; Flower 1869; and others). The degree of development in the Bay of Fundy specimen is similar to that of a 650-cm male (van Bree 1967, fig. 1–2), more than in a young animal (Elliot 1901, pl. 4), less than in an old male (Turner 1912, figure p. 81). The anterior end of the maxillary crest in NMC 42836 ascends from the rostrum at a point posterior to the anterior tip of the vomer. The asymmetry of the floor of the narial basin extends to halfway along the maxillary crests, with the right premaxillary appreciably overlapping the mesorostral gutter. The vomer is without a mesorostral ossification (see

TABLE 2. Cranial measurements of stranded bottlenose whale from Cobequid Bay, October 9, 1969. All figures are in millimeters; approximations are in parentheses. (Numbers are those used by Moore 1963; some terms modified.)

Measurements	
1. Total length	(123.7)
2. Greatest length of rostrum	(77.3)
3. Tip of rostrum to posterior margin of pterygoid nearest midsagittal plane	(89.4)
4. Tip of rostrum to most posterior wing of pterygoid	(95.1)
5. Tip of rostrum to most anterior extension of pterygoid	(63.2)
6. Tip of rostrum to most posterior extension of maxillaries adjacent to palatines	(63.1)
7. Tip of rostrum to most posterior extension of maxillary plate	(118.5)
8. Tip of rostrum to anterior margin of superior nares	(96.2)
9. Tip of rostrum to most anterior point on premaxillary crest (i.e. to anterior tip of nasals)	(99.7)
10. Tip of rostrum to most posterior extension of temporal fossa	(116.4)
11. Tip of rostrum to most posterior extension of lateral tip of left premaxillary crest	(105.8)
12. Tip of rostrum to most anterior extension of pterygoid sinus	(89.3)
13. Greatest length of temporal fossa	(22.2)
14. Greatest length of orbit	(15.2)
15. Greatest length of right nasal bone on vertex of skull	6.6
16. Length of nasal suture	(3.2)
17. Greatest breadth of skull across postorbital processes of frontals	67.2
18. Greatest breadth of skull across zygomatic processes of squamosals	61.6
19. Least breadth of skull across centers of orbits	63.5
20. Least breadth of skull across posterior margins of temporal fossae	40.4
21. Greatest breadth of occipital condyles	25.2
22. Greatest width of an occipital condyle	12.0
23. Greatest length of an occipital condyle	18.2
24. Greatest breadth of foramen magnum	8.5
26. Greatest breadth of nasal bones on vertex	11.0
27. Least distance between premaxillary crests	3.9
29. Greatest span of premaxillary crests	28.2
30. Least transverse width of premaxillae where they narrow anterior to superior nares	5.6
31. Greatest width of premaxillae anterior to place of preceding measurement	12.6
32. Width of premaxillae at midlength of rostrum	—
33. Width of rostrum in apices of antorbital notches	36.6
34. Width of rostrum in apices of prominential notches	(28.9)
35. Greatest width of rostrum at midlength of rostrum	—
36. Greatest depth of rostrum at midlength of rostrum	—
37. Greatest transverse width of superior nares	8.6
38. Greatest internal width of inferior nares at apices of pterygoid notches on the pterygoids	12.8
39. Height of skull, vertex to most ventral point on pterygoids	50.4
39a. Height of skull, maxillary crests to most ventral point on pterygoids	53.6
40. Greatest width of temporal fossa at right angle to greatest length	(7.0)
41. Least distance between main or anterior maxillary foramina	6.6
42. Least distance between premaxillary foramina	(3.8)
43. Distance from posterior margin of left maxillary foramen to most anterior extension of left maxillary prominence	17.0
44. Greatest length of vomer visible at surface of palate anteriorly	(16.3)
– Least distance between dorsoposterior margin of maxillary crest, and anterodorsal extension of left premaxillary, dorsal to external nares	8.2

Fraser 1942). The synvertex or rostral crest (posterior ends of premaxillaries and nasals; Fig. 2, 4) slightly covers the external nares in dorsal view. The synvertex shows all the characteristics detailed by Moore (1968, fig. 16 legend; apparently same skull as Elliot 1901, pl. 4). In comparison with the basicranium of a smaller Irish specimen (Fraser and Purves, 1960, pl. 8) differences can be related to

TABLE 3. Measurements of jaws and teeth of a stranded bottlenose whale from Cobequid Bay, October 9, 1969. All figures are in centimeters and approximations are in parentheses.

Measurements	Left	Right
Greatest length of dentary bone	108.6	(107.9)
Greatest length of dentary to posterior end of symphysis	76.7	76.4
Greatest length of dentary to posterior border of mental foramen	84.6	84.5
Greatest length of dentary to anteromedial margin of mandibular vacuity	74.6	(74.0)
Height at coronoid process	18.8	19.2
Breadth of mandible at posterior margin of mandibular symphysis	11.9	
Breadth of jaws across mandibular condyles	56.2	
Total length of tooth	3.876	(3.730)
Greatest diameter of tooth	1.321	(1.225)
Diameter at right angle to greatest diameter	1.258	(1.200)

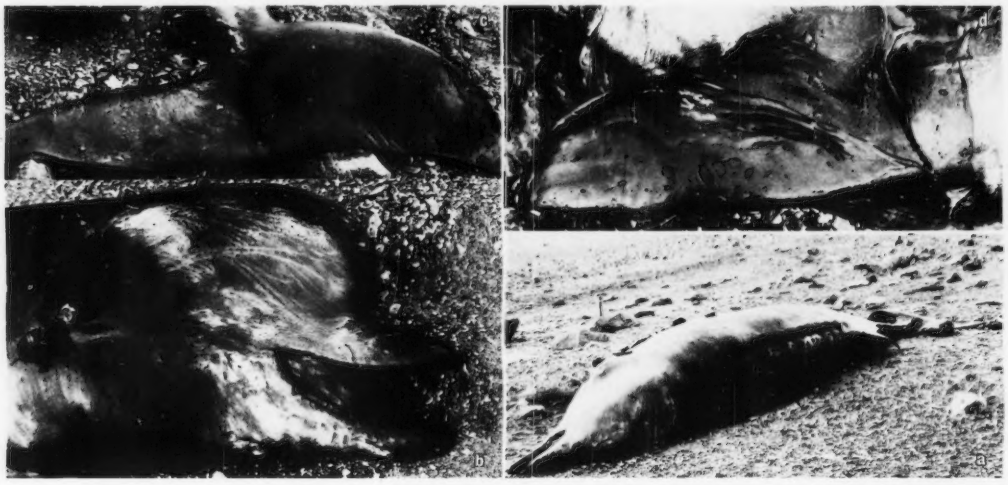

FIG. 1. Carcass of northern bottlenose whale, *Hyperoodon ampullatus* (Forster, 1770), washed ashore in Cobequid Bay, Bay of Fundy, before October 9, 1969. a, Carcass on October 19, 1969, when measured by Kozicki (*cf.* Case and Densmore 1970, their photos on p. 19 taken previously); b, Size of melon and shape of snout; c, flukes; d, Right pectoral.

relative age or individual variation, for example the thicker vomer with a squarer notch in its posterior margin.

The tympano-periotic complex (Fig. 5; Table 4) is similar to that described by Kasuya (1973, his terminology). The bulla is cylindrical, relatively wide and broad for its length. The ventral floor has an anterior edge that is broadly curved in ventral view and not developed into an anterior spine, but which is relatively thin-edged and progressively sharper externally. The outer prominence is projected into a distinct, sharply angled shoulder, but the interprominential notch is very shallow, and a median furrow is discernible. The left tympanic bulla resembles that illustrated by Turner (1912, figure on p. 83) except that it is not quite so rugose, the outer prominence is sharper, and the involucrum is slightly different in curvature. The lateral furrow is deep and conspicuous. In the left bulla, a thin, transverse sheet of bone remains, partly closing the elliptical foramen (Kasuya 1973, p. 53).

The auditory ossicles are suspended between the sigmoid process of the tympanic bulla and the periotic (Hunter 1787), with the stapes not ankylosed in the fenestra ovalis (Fraser and Purves 1960). On the left bulla, the malleus is still connected to it. (The right

FIG. 1e. Field photograph of bottlenose whale taken by J. S. Bleakney on October 7, 1969, showing location of barnacles collected. (Photo courtesy S. Bleakney.)

malleus and the incus from both sides were lost in preparation.) The malleus resembles that illustrated by Doran (1879, pl. 62, fig. 35), and the stapes has crura that are fused, with an imperforate stapedial foramen (Fig. 5).

MANDIBLE

The two rami of the mandible (Fig. 3; Table 3) are not ankylosed at the symphysis. The alveolus for the main tooth is at the distal end, and it is deep, not filled in as described by Moore (1968, p. 250–252) for an aged male. It is continuous with the alveolar or dentinal groove, which extends farther than halfway back between the coronoid process and the proximal end of the symphysis. In lateral view, there is little break in slope of the alveolar groove, midway from coronoid process to the symphysis, as there is in *H. planifrons* (Fraser 1945, fig. 1), but this may be an age or sex feature.

TEETH

Any vestigial teeth (e.g. Boschma 1950, 1951; Fraser 1953) were lost in preparation by boiling. Two main teeth in the lower jaw are conical, sharply pointed, and tipped with enamel (Fig. 5; Table 3). Moore (1968, fig. 6) illustrated a tooth in situ in an adult male, and Owen (1840–45, vol. 1, p. 347, vol. 2, pl. 88) showed the dorsal surface of the jaw, with teeth in place, of an "immature *Hyperoodon bidens*" (apparently *H. ampullatus*, i.e. the bottlenose whale of J. Hunter, Hershkovitz 1966, p. 147). The Bay of Fundy specimen resembles the latter, especially in the shape and orientation of the alveolar grooves. It differs in that the alveoli for the rows of small vestigial teeth are not clearly demarcated by septa, the distal tip of the mandible is less rugose, more porous (with some breakage around the main alveoli as a result of preparation), and possibly the main teeth were directed more anteriorly. The main alveoli are much larger than is the base of the (e.g. right) tooth. The teeth have unworn crowns. The "slight but definite bulbousness at the proximal end," characteristic of this species, is slight, not definite (see upper left pair in fig. 5, Moore 1968, not identified or marked for scale). The pulp cavity is open. Evidently, it closes with age. Moore (1968, p. 236) observed one with the pulp cavity entirely filled at the root, and others are known (e.g. Christensen 1973, fig. 1). The "finger-like projections forming the rim around the pulp cavity" noted by Moore (1968, p. 234) are present. Actually they comprise flutes or laminae attached to the wall of the pulp cavity, and extend proximally to project out of the pulp cavity. These projections are distinctly set off from the distinct, sharply edged and irregular proximoexternal edge of the tooth. They contribute to the thickness of the base of the tooth. The distal end of the tooth is thin enough to transmit much light, when observed through the pulp cavity.

GROWTH LAYERS IN TEETH

Owen (1840–45, vol. 1, p. 355, vol. 2, pl. 89) noted the "concentric layers of dentine" in odontocete teeth, and these have been described in *H. ampullatus* as clear and easily counted (Benjaminsen 1972). Christensen (1973) has presented much original data on growth layers in the teeth of bottlenose whales taken in the Norwegian pelagic fishery for small whales in the North Atlantic Ocean. Some of his samples are from whales collected from the northwest Atlantic, especially in the Labrador Sea. Whether the population off Nova Scotia is the same as that sampled by Christensen in the Labrador Sea in unknown. Christensen discussed growth and tooth structure, including the alternation of light and dark laminae in the teeth and their relative width, and related those structures to the accumulation of corpora in the ovaries of a small sample of females. However, Christensen has stated that "because all the teeth were collected during the months of May and June it was not possible to trace the accumulation of dentine throughout the year" in his sample (Christensen 1973, p. 333). It is therefore of interest to examine the tooth of the autumn Nova Scotia whale in order to confirm that the width and sequence of growth zones corresponds to those in the sample of Christensen. Examination of a longitudinal section of the left tooth (Fig. 6) shows growth layers in the dentine. We count a minimum of five growth layers internal to the zone of dark, easily identified, prenatal dentine. The last zone deposited is darker and narrower than the previous four. Microstructure of the last zone differs somewhat from the three teeth illustrated by Christensen (1973, fig. 1). He noted that the major growth decreases after the deposition of 8–12 growth layers, with concurrent,

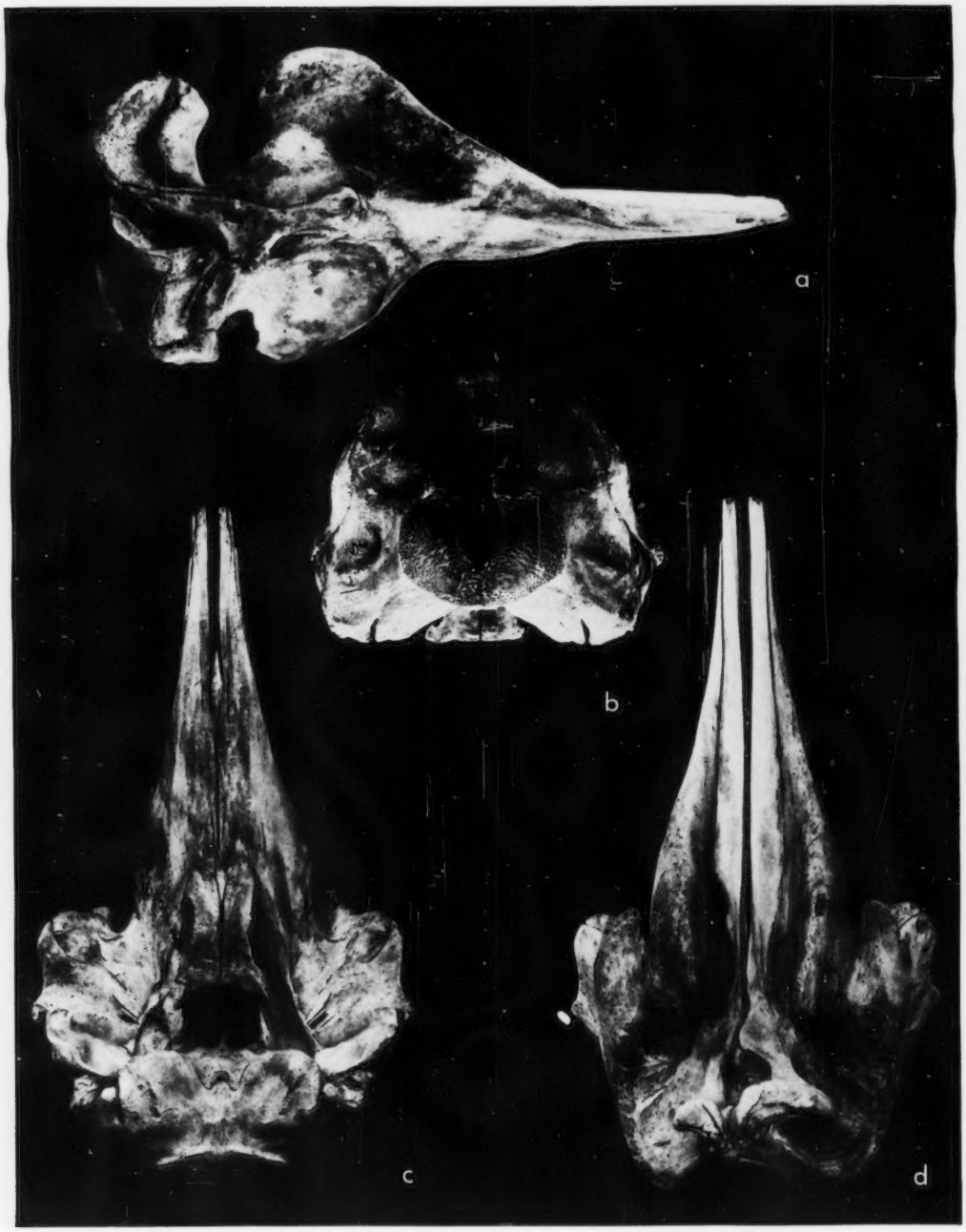

FIG. 2. Skull of Cobequid Bay *Hyperoodon ampullatus*, N.M.C. 42836. a, Right lateral view; b, Posterior view; c, Ventral view; d, Dorsal view. Scale is 10 cm in length.

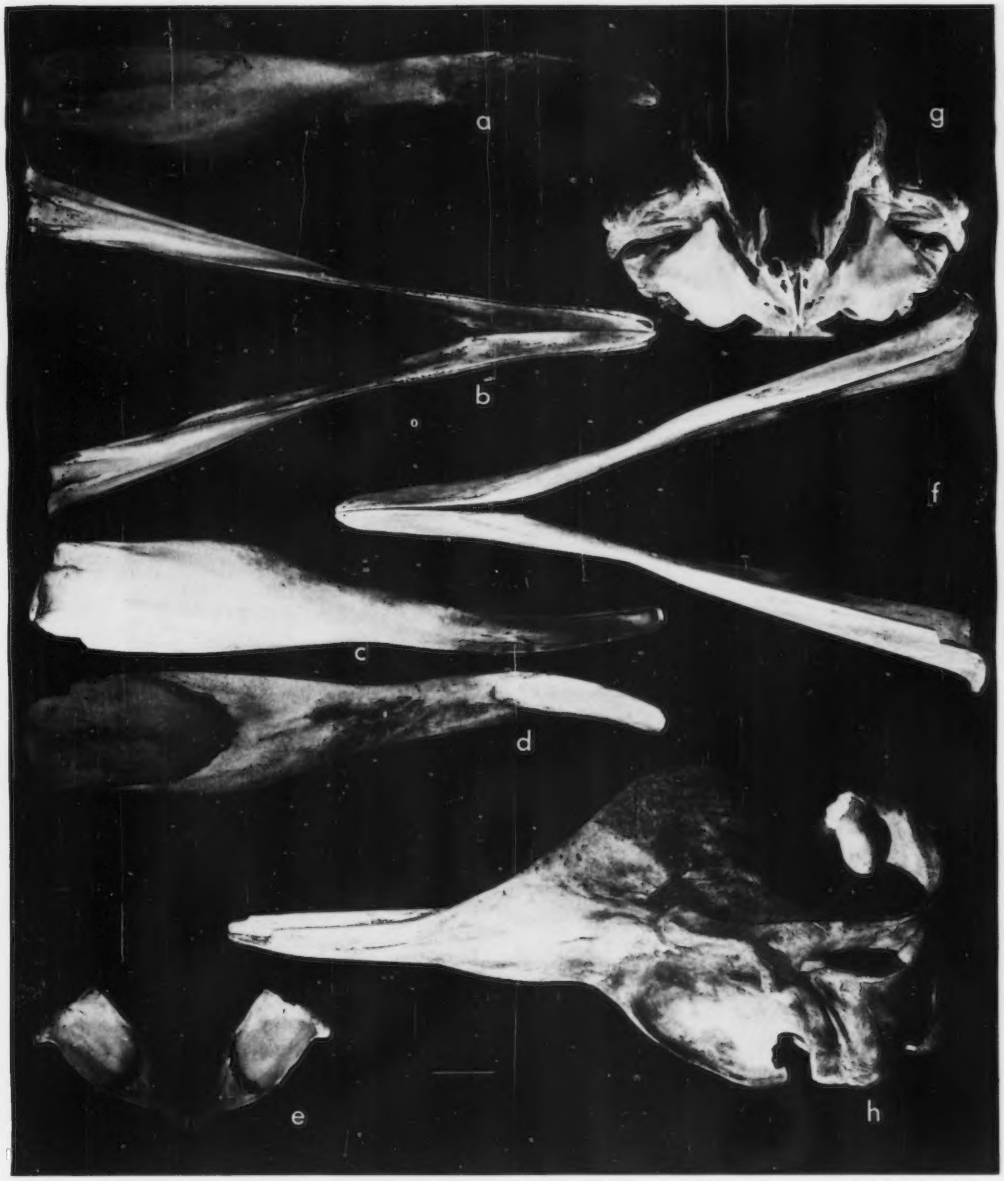

FIG. 3. Skull and mandible of Cobequid Bay *Hyperoodon ampullatus*, N.M.C. 42836. a, External view of left dentary; b, Dorsal view of mandible; c, External view of right dentary; d, Internal view of right dentary; e, Posteroventral view of mandible; f, Ventral view of mandible; g, Anterior view of skull and mandible; h, Left lateral view of skull. Scale is 10 cm in length.

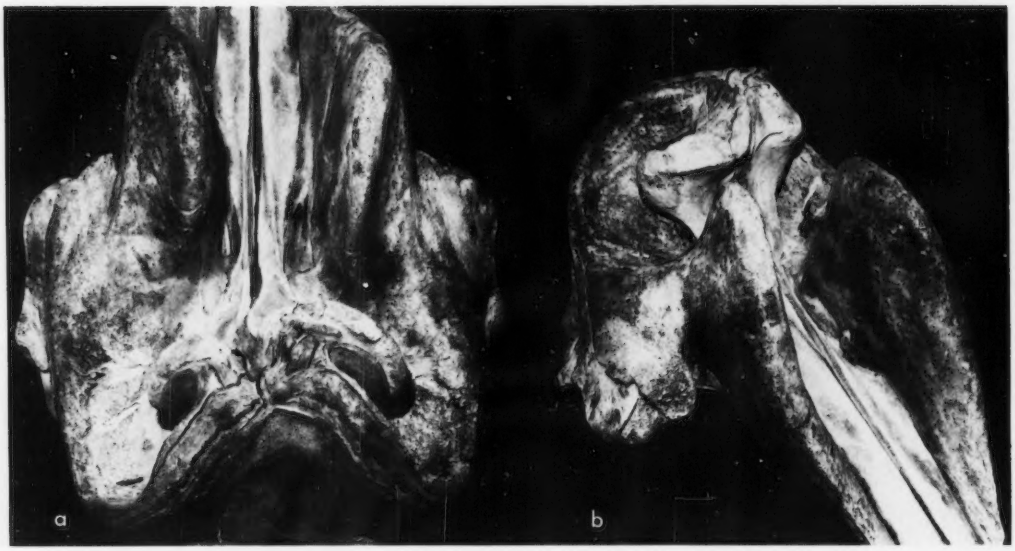

FIG. 4. Skull of Cobequid Bay *Hyperoodon ampullatus*, N.M.C. 42836. a, Detail of vertex; b, Right dorso-anterolateral view of skull. Not to same scale.

gradual filling of the pulp cavity with dentine. In males, the thickness of each dentine layer decreases from the first to the fourth layer and then is constant to layer number 11. In our specimen the first, outermost light lamina is slightly thinner than the second and third laminae, and subequal with the thickness of the fourth light lamina; the fifth (innermost) light lamina is appreciably narrower. Assuming a total count of five growth layers, the length of our whale (615 cm) falls below the growth curve of Christensen (1973, fig. 8). Ignoring the darkness of the internal lamina as an artifact, we conclude that it represents spring (Christensen 1973, p. 337) and summer growth of 1969. Then by this interpretation, the more quiescent period of growth began before October, resulting in deposition of a thin dark lamina in autumn and this is represented by the thin, dark lamina observed on the surface of the pulp cavity.

GENERAL DISTRIBUTION IN NORTHWEST ATLANTIC

Miller and Kellogg (1955) give the range in the western North Atlantic as from Davis Strait (Brown 1868), south side of lower St. Lawrence River near Cape Martin, Kamouraska County, Que. (Beaugé 1942), to North Dennis, Mass. (Allen 1869) and Narragansett Bay near Tiverton, R.I. (Cope 1869).

The species was not mentioned by either Low (1906) or Bernier (1910), both of whom summarized information regarding whaling in Davis Strait. It was not previously known to be an inhabitant of the Gulf of St. Lawrence by St. Cyr (1886). Van Beneden (1888, p. 69) said that "Reinhardt fait observer qu'un Hypéroodon a échoué sur la côte des États-Unis d'Amérique, sous le nom de *Mesoplodon Sowerbyi*." A fishery for bottlenose whales was prosecuted in the middle 1960s off Sable Island, early in the spring and summer months. Few records were available of other sites of concentration of the bottlenose whale in spring, but we found a concentration off Cape Chidley on the May–June 1969 cruise of the *Polarstar* where Lindsay (1911) and others took them. We have other information at hand indicating that bottlenose whales occur in the vicinity of Sable Island and The Gully at other times of the year, notably in the late summer and autumn months. (For

FIG. 5. Tympano-periotic, auditory ossicles, teeth and jaw of Cobequid Bay *Hyperoodon ampullatus*, N.M.C. 42836. Scale (under *e,f*) for *a-q* and *z-ad* is 1.0 cm in length, other scales as mentioned below. *a-f*. Posterior, dorsointernal, dorsal, ventral, dorsoanterior and anterior views of right tympanic bulla. *g-k*. Dorsal, external, posterior, internal and anterior views of left tympanic bulla with attached malleus. *l-q*. Ventral, internal, dorsal, external, posterior and anterior views of right periotic. *r-u*. Dorsal, external, ventral and internal views of right mandibular tooth (scale = 0.5 cm). *v,w*. Oblique ventroposterior and dorsoposterior views of left mandibular tooth (tip cut off in photo), before sectioning. *x,y*. Lateral and cranial views of left stapes (scale = 0.2 cm). *z,aa-ad*. Right mastoid. *ae*. Anterodorsal view of mandibles (not to same scale).

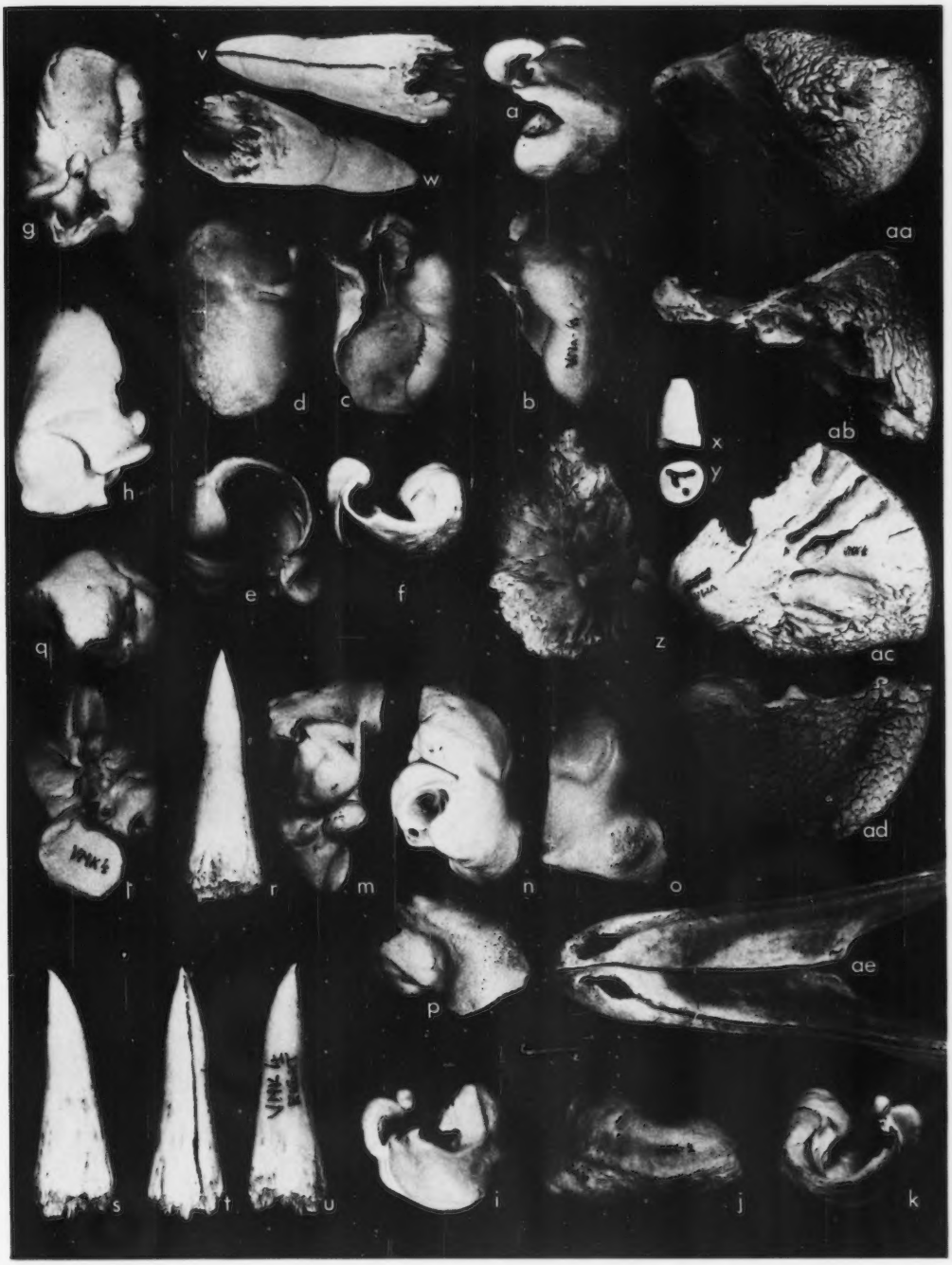
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TABLE 4. Measurements and weights of auditory bullae, periotics and ossicles of Cobequid Bay *H. ampullatus*, NMC 42836. Numbers and measurements after Kasuya 1973; measurements in centimeters, approximations in parentheses. Weights in grams.

Measurements	Left	Right
Tympanic bulla:		
1. Standard length of tympanic bulla, distance from anterior tip to posterior end of outer posterior prominence	6.064	6.275
2. Distance from anterior tip to posterior end of inner posterior prominence	(5.250)	(5.350)
3. Distance from posteroventral tip of outer posterior prominence to tip of sigmoid process	4.190	4.310
4. Distance from posteroventral tip of outer posterior prominence to tip of conical process	3.110	3.327
5. Width of tympanic bulla at the level of the sigmoid process	3.910	3.899
6. Height of tympanic bulla, from tip of sigmoid process to ventral keel	4.286	4.320
7. Width across inner and outer posterior prominences	3.725	3.720
8. Greatest depth of interprominential notch	0.140	0.176
9. Width of upper border of sigmoid process	1.870	1.891
10. Width of the posterior branch of lower tympanic aperture	—	0.548
11. Greatest diameter of elliptical foramen	0.985	(0.995)
Periotic:		
13. Standard length of periotic, from tip of anterior process to posterior end of posterior process, measured on a straight line parallel with cerebral border	6.445	6.579
14. Thickness of superior process at the level of upper tympanic aperture	3.431	3.425
15. Width of periotic across cochlear portion and superior process, at the level of upper tympanic aperture	3.630	3.695
16. Least distance between the margins of fundus of internal auditory meatus and of aperture of ductus endolymphaticus	0.084	0.085
17. Least distance between the margins of fundus of internal auditory meatus and of aperture of aquaeductus cochleae	0.180	0.148
18. Length of the articular facet of the posterior process of periotic for the posterior process of tympanic bulla	2.548	2.628
19. Anteroposterior diameter of cochlear portion	2.907	2.840
Auditory ossicles:		
Maximum diameter of head, malleus	0.835	—
Minimum diameter of head, malleus	0.545	—
Total length of malleus	(1.090)	—
Maximum width of articular facet for incus, on malleus	0.527	—
Maximum length of stapes	0.584	0.590
Maximum diameter of footplate, stapes	0.385	0.383
Minimum diameter of footplate, stapes	0.336	0.341
Weights		
Tympanic bulla	47.91	49.70
Periotic	74.20	75.66
Stapes	0.0917	0.0876
Ratios		
Length of bulla as percentage of length of periotic	94.1%	95.4%
Weight of bulla as percentage of weight of periotic	64.6%	65.7%

example we know of at least one whale taken in the Nova Scotia fishery in October of 1964 – see Mitchell 1975, p. 54, summary of data from *International Whaling Statistics*). Thus, although there are two sites of concentrations of bottlenose whale in the early summer and spring on the Canadian coast (Sable Island area, and northern Labrador area), there is at least one area of known occurrence later in the sum-

FIG. 6. Midsagittal section of left main anterior tooth of Cobequid Bay *Hyperoodon ampullatus*, N.M.C. 42836. a, Dorsoposterior surface of tooth to left. b, next adjacent section, dorsoposterior surface of tooth to right. Scale is 10 mm in length. Both sections approximately 125 μ thick, placed in acetate holder with oil bath, and used as a negative with transmitted light in ordinary darkroom enlarger. Note large pulp cavity, thin enamel cap on tip, osteodentine between pulp cavity and enameled tip, and growth layers in cementum around base which are more difficult to read than the sharp dentinal layers. Darkness of most recent translucent lamina is an artifact of lighting. This most recent lamina is bounded by double opaque laminae. (Note: The translucent laminae appear dark, opaque laminae light, in this photograph.)

a
b

TABLE 5. Some occurrences of the northern bottlenose whale, *H. ampullatus*, on the coast of North America. Early, and other doubtful records are not listed. Not all are naturally occurring strandings, some are captures in inshore waters. Abbreviations are: MANS, Museum of Academy of Natural Sciences, Philadelphia; MCZ, Museum of Comparative Zoology, Harvard University; NMC, National Museum of Canada, Ottawa.

Record no.	Locality and approximate latitude	Evidence	Date of stranding	Date of discovery or collection	Total length	Sex	Authority	Remarks
1.	Cap Martin, Que. Gulf of St. Lawrence (49°00′N)	Photo	Sept. 4, 1940	Sept. 4, 1940	22 ft 1 inch (673 cm)	♀	Beaugé 1941	Live when captured in river
2.	Dildo Arm, Trinity Bay, Newfoundland (47°35′N)	—	July 27, 1953	July 27, 1953	≃22 ft (≃670 cm)	♂	I. Iversen, pers. comm. to Sergeant and Fisher 1957	Companion escaped, seen for 3 days
3.	Cobequid Bay, Bay of Fundy (45°20′N)	Cranium, photos, measurements (NMC 42836)	Oct. 5–9, 1969	Oct. 9, 1969	20 ft 3 inches (615 cm)	♂	Case and Densmore 1970; this paper	Stranding not observed, examined long after death.
4.	South Beach, near west end of Wallace Lake, Sable Island (43°50′N)	Measurement only	Feb. 1 or 2, 1974	Feb. 2, 1974	≃27 ft (≃823 cm)	♂	B. Beck, pers. comm. 7 III 1975	"Fresh"
5.	South Beach ca 2 miles E. of east end of Wallace Lake, Sable Island (43°50′N)	Measurements	? Jan. 1968	Jan. 12, 1968	29 ft (870 cm)	♂	Sergeant, Mansfield and Beck 1970	Stranding not observed
6.	Wells Beach, Maine (43°20′N)	Body cast in Boston Soc. Nat. Hist.	Mar. 2, 1906	—	15 ft (450 cm)	♂	Anon. 1906, p. 4. Norton 1930, p. 105.	Cast by Brown (1913, p. 8).
7.	Beverly Farms, Massachusetts (42°33′N)	Skeletons (MCZ 25361, 25362)	Oct. 1923	collected by T. Barbour	Young Adult	♂ ♀	E. Rutzmoser, pers. comm., Mar. 14, 1975 Barbour 1943, p. 246–247.	Stranded alive, Received at MCZ in 1929 from T. Barbour.

TABLE 5 (*Concluded*)

Record no.	Locality and approximate latitude	Evidence	Date of stranding	Date of discovery or collection	Total length	Sex	Authority	Remarks
8.	North Dennis, Massachusetts (41°45′N)	Outline by J. H. Blake; Sketch by Perez Hall; Skeleton MCZ 1207.	Jan. 29, 1869?	Jan. 29, 1869 J. H. Blake, and/or Perez Hall	25 ft (761 cm)	♂	Allen 1869, vol. 1, p. 205; Cope 1869, p. 32; J. H. Blake *in* Goode 1884, p. 18; True 1910, p. 2, 76; Ulmer 1941, p. 120.	Blood still warm when found on beach. Cope gives 24 ft. Skull illustrated by Norris (1964, figs. 1–3).
9.	Newport, Rhode Island (41°30′N)	Skull, other bones, and photographs, MANS, Philadelphia	Feb. 1867	Feb. 1867 Saml. Powell	27 ft (823 cm)	♀	Cope 1869, p. 31–32, pl. 1; Allen 1869, p. 206; True 1910, p. 2, 76, pl. 32, fig. 3; Ulmer 1941, p. 120.	Two individuals, one captured. True cited record as "1869". Cope illustrated it as "*Hyperaodon* of Narragansett."

mer (again the Sable Island area) and we presume that the same population as was fished from Nova Scotia is involved. In The Gully its occurrence is predictable enough that acoustic eavesdropping has been carried out on it there (Beamish and Mitchell in preparation; Winn et al. 1970, an August occurrence).

Occurrences on the North American Coast

Few specimens have stranded. Some have been captured. Available data are summarized in Table 5. They are mentioned in order from north to south:

1) One specimen stranded alive on September 4, 1940 was briefly described by Beaugé (1941), from Sainte-Anne-de-la-Pocatière, Cap Martin, Gaspé Peninsula, Que., in the Gulf of St. Lawrence. Identification was made by Beaugé on the basis of belly color, presence of snout, and bulbous melon. It was a 22-ft 1-inch (673-cm) female, and was subsequently accepted and cited by Sergeant and Fisher (1957), and Sergeant et al. (1970). No specimen is known to have been preserved.

2) At least two bottlenose whales came into Dildo Arm, Trinity Bay, Nfld. on July 27, 1953. One was captured by the small whale hunters there, a 22-ft male (Sergeant and Fisher 1957). The scarcity of this species in catches of the active small whale fishery in Trinity Bay was presumably due to the absence of the whale in that area. No specimen is known to be preserved. This record was subsequently cited by Sergeant et al. (1970).

3) Bay of Fundy specimen, described above. The carcass was seen on the beach by Mr M. Densmore on October 9, 1969 (Case and Densmore 1970), who subsequently told Kozicki that it had come ashore on the high tide after Sunday, October 5. The first newspaper article was a photograph with caption (*The Chronicle-Herald*, Halifax, October 18), and the same photograph is reproduced in Case and Densmore (1970, p. 19, upper), who also cite the second newspaper article. External measurements are in Table 1.

4) B. Beck informed us (personal communication March, 1975) that he and G. Sleno of the Arctic Biological Station, while carrying out field work on Sable Island under direction of Dr A. W. Mansfield, observed a recently stranded carcass of a bottlenose whale on the south beach, slightly west of the west end of Wallace Lake on February 2, 1974. They had traversed this area shortly before, and the whale was not there then. As they were departing the island by aircraft, only the sex and a hurried estimate of the total length was observed. No specimens were collected.

5) One 870-cm male was found on the south beach of Sable Island by A. W. Mansfield and B. Beck on January 12, 1968 (Sergeant et al. 1970), approximately 2 miles (3.2 km) east of the east end of Wallace Lake (G. Sleno, personal communication, March 7, 1975). Body measurements are presented by Sergeant et al. (1970) but no specimens were collected. The carcass remained on the beach until 1970 or 1971, and might yet be buried in the sand although subsequent efforts to locate it proved futile (G. Sleno, personal communication, March 11, 1975). Sergeant et al. (1970) speculated that the carcass might have been that of an animal killed by small whale hunters from Nova Scotia. Then, the carcass must have been old as the fishery was prosecuted only in June in 1967, and terminated that year (Mitchell 1974, p. 163; 1975, p. 54); however, we think that their speculation is unlikely. Since B. Beck informed us (personal communication, March 7, 1975) that the carcass appeared to be fresh, but frozen, we conclude that the record represents a "natural" death and stranding.

6) A young male, about 15 ft (4.6 m) long, came ashore at Wells Beach, Maine and a body cast was made for the Boston Society of Natural History (Brown 1913). Norton (1930) mentioned this March 2, 1906 stranding, and cited Anon. (1906) as a source.

7) Ms E. Rutzmoser of the Museum of Comparative Zoology, Harvard University (personal communication, March 14, 1975) gave us catalogue information regarding two skeletons from one stranding at Beverly Farms, Mass. in October 1923. A young male (MCZ 25361) and an adult female (25362) were collected by T. Barbour, who deposited the skeletal material in the MCZ in 1929. Barbour (1943, p. 246–247) stated that "two beaked whales chasing fish on a falling tide got stranded quite near where we live in summer. Their uncannily human groans, deep sobbing sounds, were audible half a mile away, and had kept the neighbors uneasily awake."

8) The only early record for Massachusetts (Brown 1913) is a fresh male carcass 25 ft (7.6 m) in length found on the beach at North Dennis, Mass. on January 29, 1869. Cope (1869, p. 32) gives the following information regarding this occurrence:

> "This is the skeleton preserved in the Museum Compar. Zoology at Cambridge, Mass. of an individual cast ashore during the winter of the present year, at Dennis, near Cape Cod, Massachusetts. It was stripped of its blubber by Perez Hall, of that place, who kindly sent me a sketch of it. He stated its length to be twenty-four feet, of which the muzzle measured twenty-two inches: the expanse of the flukes was six feet. The stomach was filled with the beaks of cuttle fish. On inquiry of J. A. Allen, of Cambridge, well known as a naturalist there, I learn that the cervical vertebrae of the animal are solidly coossified, as in the *H. rostratus*."

Allen (1869, vol. 1, p. 205) gives the following regarding the same occurrence: "A specimen referred by Professor Cope to this species came ashore at North Dennis in January, 1869; its skeleton, secured by Mr J. H. Blake, is now in the Museum of Comparative Zoology." Goode (1884, p. 181) gives the following on the same record:

> "A specimen twenty-five feet long of this animal, *Hyperoodon bidens* Owen, was found on the beach at North Dennis, Mass., January 29, 1869; ... I am indebted to Mr J. H. Blake for an outline of this cetacean, and the follow-

ing notes, taken by him at the time, he having visited Dennis and obtained the skeleton for the Museum of Comparative Zoology: 'When found', he writes, 'the blood was still warm. It was twenty-five feet long, six feet high, and the tail was six feet across. The flippers were twenty-nine inches long, the snout twenty inches. The hump on the back was three or four inches high, thick at the base and narrowing toward the tip. The blubber was two and a half to four inches thick and sold for $175. Squid-beaks enough to fill two water-buckets were taken from the stomach."

True (1910, p. 2) repeats this information and accepts the record:

"North Dennis, Massachusetts. January, 1869. Male. Skeleton in the Museum of Comparative Zoölogy, Cambridge, Massachusetts," as does Ulmer (1941, p. 120):

"North Dennis, Massachusetts. January, 1869. Male. Skeleton in the Museum of Comparative Zoölogy, Cambridge, Massachusetts. J. A. Allen, Bull. Mus. Comp. Zoöl., vol. 1, 1869, p. 205."

The skull, MCZ 1207 (E. Rutzmoser, personal communication, March 14, 1975) is illustrated by Norris (1964, figs. 1–3).

9) All American writers agree that the southern extent of the range, as known from strandings, is Rhode Island. There, "there are three authentic records of bottlenosed whales in Rhode Island waters. Two of these records are from Tiverton, and one from Newport" (Cronan and Brooks 1968, p. 77). We find the literature confusing on this point, and, without search of museum collections and files, find information bearing on only one Rhode Island occurrence. Cope (1869, p. 31–32, pl. 1) gives the following information:

"Two years ago two individuals of this genus entered the harbor of Newport, R.I. and after a lively chase one of them was captured. It measured twenty-seven feet in length. Its bones were preserved, and some of them including the cranium, have been sent to the Academy of Natural Sciences, through the attention of its member, Saml. Powell, of Newport. He has also sent numerous photographs of its carcass, taken just after its capture, from various points.

These render it evident that the species is quite distinct from that described by European authors as *H. rostratus* (or *H. bidens*). Its most striking feature is the relatively longer and more slender beak, and less elevated and prominent front. ... Thus, in the Newport specimen, it is one-twelfth of the length, or 2¼ feet; equal three-fourths the distance between the eye and the spout hole. ... The prominent swollen front is in the Newport whale, considerably compressed, and the eye is placed in a strong longitudinal prominence on each side of the head.

The dorsal fin, ... is small, and posterior. The caudal fluke is not emarginate. The color is dark, deeper above than below ... The cervical vertebrae of the Newport specimen are entirely coösified. ...

The photographs are figured for the further illustration of the species. The characters derived from the portions of the skeleton sent by Saml. Powell are as follow: [incomplete]"

Cope attached Plate 1 to this account, with three views of the "Hyperaodon of Narragansett." That these were based upon photographs, as stated, is confirmed since at least one of the photographs has been published elsewhere. This is in "The Cetacea" by Cope (1890, p. 608), published without comment except for the legend, "*Anarnacus rostratus* Wesm, from a photograph taken at Newport, R.I." This photograph clearly served as a model for the bottom illustration in Cope (1869, pl. 1), and shows an undoubted *H. ampullatus*. Another reference (Anon. 1869, p. 191–192) to the same capture repeats the data:

"Prof. Cope made some remarks on a cranium of the *Hyperaodon bidens*, from the coast of Rhode Island, presented by Samuel Powell, of Newport. He stated that it was a female, which entered the harbor of the latter place with a calf. A male was some time after cast ashore dead near Dennis, Mass., and was preserved complete in the Mus. Comp. Zoology, Cambridge. (See Allen, Mammals Massachusetts.) He said that the muzzle of the female was longer than represented for European specimens, but that that of the male was as short, and that no difference could be detected in the skeleton of either. He therefore retained the name of *H. bidens*. He stated that *Mesoplodon sowerbiensis* also occurred on the coast of Nantucket."

Allen (1869, p. 206) stated only that "a few weeks later Professor Cope obtained another that was stranded near Newport, R.I.," thus apparently confusing the year with the 1869 North Dennis stranding. Goode (1884, p. 18) refers to the record as "obtained in 1866 or 1867 at Tiverton Stone Bridge, R.I."

True (1910, p. 2) quotes the record as: "Newport, Rhode Island. 1869. Female. Skull in Museum of the Academy of Natural Sciences, Philadelphia," and illustrated the skull (1910, pl. 32, fig. 3). True incorrectly gives the date as 1869 instead of 1867, but Ulmer (1941, p. 120) gives the record as: "Narragansett Bay near Tiverton, Rhode Island. 1867. Female. Skull and "other bones" at the Academy of Natural Sciences of Philadelphia, Philadelphia, Penna. E. D. Cope, Proc. Acad. Nat. Sci. Phila., vol. 21, 1869, p. 31."

Thus a single occurrence (of two animals, one of which escaped) has been referred to as:

Newport, 1867.
Narragansett, 1867.
Tiverton Stone Bridge, 1866 or 1867.
Newport, 1869.
Tiverton, 1867.

and may have created some confusion.

Unacceptable Records

Aside from some confusion in published literature regarding details of strandings of *Hyperoodon ampullatus*, some records clearly refer to other cetacean species. Mentioned from north to south, some of these are:

A. Linsley (1842, p. 353) described a record of a putative bottlenose whale at Stonington, Connecticut, but Ulmer (1941, p. 120) correctly doubts the validity of the record. Specifically, Linsley gives:

> "*67. *Rorqualus costatus*, Dekay, Beaked Whale, Stonington," and
>
> "*67. Of the beaked whale, it may be said that a specimen sixteen to eighteen feet in length, was taken in Raritan Bay in 1822, and hence we may infer that the east end of our Sound would be as likely to receive such an occasional visitor as that bay; especially as he is said to be 'found in most parts of the Northern Atlantic.'"

but DeKay's beaked rorqual (*Rorqualus rostratus*) is definitely a minke whale (see below).

B. Occurrences have been reported of this species in the Long Island region, including locations in Lower New York Bay, the south shore of Long Island, and the Connecticut coast of Long Island Sound, "but, for one reason or another, all such published reports are incorrect as far as I know" (Connor 1971, p. 44). True (1910, p. 2) cited without comment a record as follows: "New York Bay, New York. 1822. Female (?). Not known to have been preserved." If this is the same record that Ulmer (1941, p. 120) cited, and concluded that "because of the confusion that formerly existed amongst the Ziphiidae, little faith can be put in this record," there can be little doubt that it does not relate to a bottlenose whale. This is definitely the record that Murphy (1914) identified as a bottlenose whale, stating that DeKay (1842) also published "a more or less unrecognizable lithograph of the species." DeKay (1842, vol. 1, p. 130–131) clearly described an 18-ft (5.5-m), female (?) whale captured in the "lower bay of New York" in 1822, that had white baleen, no teeth, notched flukes, and "swimming paws white in the middle, black at the base and extremities," a completely acceptable record of the minke whale, *Balaenoptera acutorostrata*.

C. Rockwell (1914) published a description of the stranding of an adult female, 17 ft 6 inches (5.3 m) in length and a juvenile, apparently newborn, 8 ft 3 inches (2.5 m) long. These animals came ashore at Long Beach, Long Island, New York on August 15, 1914 and another whale, "nearly white" was observed nearby but escaped. Murphy (1914) published a short accompanying note and confirmed the identification as *Hyperoodon ampullatus*. Inspection of copies of the photographs in Rockwell's article do not confirm the identification, and suggest instead *Ziphius cavirostris* because of the shape, small size, and pigmentation of the calf, the spotting on the cow, and the "nearly white" appearance of what was visible of the (?bull) whale that did not strand. This record is listed under *Z. cavirostris* by Ulmer (1941, p. 120).

D. Ulmer (1941, p. 120) reported that:

> "The unpublished diary of W. J. Hoxie records that a *"Hyperoödon vastratus"* [sic] [probably *Ziphius cavirostris*], a female, length 20 feet, containing a foetus, was found at Canaveral, Florida, August 21, 1888."

We concur with Ulmer's conclusion, in the absence of other data for the tropical distribution of this species in the western Atlantic. The minimum recorded length for pregnant females of *H. ampullatus* in the Norwegian fishery is 20 ft (6.1 m) (Benjaminsen 1972, p. 238).

Discussion

Strandings vs. captures — In the summary of nine occurrences of 12 individuals, 10 whales stranded or were captured (Table 5, no. 1–9). Of the nine, six appear to represent strandings (no. 3–8). Of the three captures, all were made with considerable difficulty or by practiced whalers (no. 1–2, 9). Two of the three (no. 2, 9) were from pods of at least two (perhaps pairs only); this information is not provided for the third (no. 1). The only isolated females in the sample are from captures (no. 1, 9), are from the northern-most (no. 1, early September) and southern-most (no. 9, February) occurrences, and may reflect somewhat the time of migration of adult females in the population represented. Many males apparently stranded singly. No mass strandings are documented in North America, but the two Beverly Farms animals stranded together alive.

Occurrence in bays and rivers — In Europe, many of the "stranding" occurrences represent lost or strayed but apparently healthy animals which swim into fjords, rivers, and streams. This also occurs in North America. Of the three captures, two were in the mouth of embayments (Table 5, no. 2, 9) and one was in the Gulf of St. Lawrence, apparently in or near a river (no. 1). In Europe, one 21-ft (6.4-m) (female?) "was caught above London Bridge in the year 1783" (Hunter 1787, p. 447–448, who also described the anatomy, and illustrated the specimen; see also Turner 1886; Fraser, various papers, and many other authors). Ruud (1937) pointed out that the bottlenose sometimes strays into shallow waters, on its southward migration, e.g. the coastal regions around the North Sea, and occasionally into the Baltic (references in Tomilin 1957, 1967). Its occurrence in the Greenland and Norwegian seas, but not the shallow Barents Sea may be due to its limitation to waters deeper than 800 fath (1440 m) (e.g. Ingebrigtsen, quoted by Ruud 1937; Jonsgaard and Øynes 1952). There have been no bottlenose taken there in

spite of an intense small whale fishery in the Barents since the mid 1940s (Jonsgaard and Øynes 1952). In September of 1939, one small herd came into the Oslofjord where one animal was stranded and shot (Ruud 1947, cited by Jonsgaard and Øynes, 1952). Many "strandings" are apparently captures of healthy animals that wandered into nearshore waters.

Distribution, seasonality of occurrence, and migration — The lack of strandings to the south of Rhode Island might be biased. The bottlenose whale might migrate south of Cape Cod, but carcasses might be so far offshore as to either sink or be transported back to the north by the Gulf Stream. However, there have been intensive surveys for marine mammal strandings south to Florida, the Gulf of Mexico, and the Caribbean (e.g. Ulmer 1961; Moore 1953; Caldwell and Golley 1965; Caldwell et al, 1971; Layne 1965; Gunter 1954; Caldwell et al. 1971; and others). These have recorded various other species of the Ziphiidae as well as sperm whales, all of which are generally deepwater, and in this area, offshore dwellers. Thus the sample appears to be adequate to conclude that there are no major concentrations of bottlenose whales offshore, south of the latitude of Rhode Island.

The spring and summer distribution is well known for the northeast Atlantic (see map in Murray and Hjort 1912, fig. 483, April–July distribution; Ruud 1937; Benjaminsen 1972, fig. 1; Tomilin 1957 (1967) and others). The southward migration, according to Risting (1922, quoted by Jonsgaard and Øynes 1952), begins in July when animals are definitely moving south from the Norwegian Sea (concentrations are known around the Faroes; Ohlin 1893) and by August (with limited numbers straggling behind until November, fide Jonsgaard and Øynes 1952) the main body has left for lower latitudes. An increase in the incidence of strandings on the British coast in autumn, with a peak in September, probably represents part of this southward migration of both sexes (Thompson 1919; Fraser 1953). Little is known in detail about the winter migration of this species. The wintering grounds "are probably situated in the warm parts of the Atlantic" and in the winter it "migrates as far south as Cape Verde, the Mediterranean Sea, New York Bay, and Rhode Island (Newport)" (Tomilin 1957, 1967, p. 403). "In the northern Atlantic they thus reach chiefly low latitudes in winter, especially in the western part of the ocean" (Jonsgaard and Øynes 1952).

If these records are valid, then the far southern limit of movement in the eastern North Atlantic, to Cape Verde (latitude 15°N) may be related to oceanographic features. In the western North Atlantic, the southern limit of distribution may be farther north (Table 5), according with the northern occurrence of the warmer waters of the Gulf Stream. We speculate that wintering grounds for *H. ampullatus* in the western North Atlantic might lie on the continental slope (and farther offshore) from Cape Cod to the Grand Bank.

As in the northeast Atlantic, winter movements of the species in the northwest Atlantic are unknown. Sergeant (1961, p. 6) suggested that "possibly it winters in the Labrador Sea," but this seems unlikely in view of the strandings to the south (Table 5). There are records of its occurrence in spring, summer, and autumn months from observations at sea and fisheries.

Lindsay (1911, p. 90) mentioned the spring fishery for bottlenose whales off Frobisher Bay (and the region of Hudson Strait and Cape Chidley), where his vessel and two others captured 27 of the whales in mid-May of one year. Many other authors have referred to this fishery. We observed bottlenose whales in the area of Cape Chidley and captured two of a small pod on June 17, 1969.

A small fishery for bottlenose whales, carried out from Nova Scotia and ultimately dropped when a large whale fishery was developed there, took 87 individuals between 1962 and 1967 (Mitchell 1974). This catch was mainly in June and July (*International Whaling Statistics*, summarized in Mitchell 1975, p. 54), with three animals caught in September and October. Most, if not all, of the catches were in "The Gully," a submarine canyon northeast of Sable Island.

These data indicate that while a concentration of early (i.e. spring) bottlenose whales occurs far to the north off Cape Chidley (as in the northeast Atlantic, where the spring migration is evidently to the highest latitudes), another concentration of whales occurs much farther south in "The Gully," in an area clearly under the influence of the Gulf Stream.

In the absence of any firm evidence for the consistent winter occurrence of bottlenose whales south of Rhode Island, we conclude from the above evidence, taken along with the two winter strandings of large males on Sable Island (Table 5, no. 4–5), that The Gully might represent an area of abundance occupied year-round by this species. We have no data to indicate whether all age- and sex-classes of one population pass through The Gully during the course of 1 yr.

The single occurrence in the Gulf of St. Lawrence (no. 1) might have been a stray from the concentration known to be in The Gully at

this time, or possibly a southward migrating animal from the concentration off Labrador that followed the Labrador current southward through the Strait of Belle Isle into the deeper waters of the Gulf. In either event, this young female is probably an extralimital stray.

Two bottlenose whales came into Trinity Bay, Nfld. (no. 2), one of which was captured. This occurrence is geographically and chronologically intermediate between the local fisheries that existed off Hudson Strait and in The Gully. In the area off the mouth of Trinity Bay, there is a broad, shoaling slope which runs far off shore before dropping more abruptly into very deep waters. Animals migrating and/or feeding northward along the slope would be diverted slightly offshore on their northward course, missing Trinity Bay, but southward migrating animals might be diverted closer into Trinity Bay due to the conformation of the local bathymetry.

The Bay of Fundy record (no. 3) probably represents a stray, or even a carcass that drifted far up into the Bay of Fundy. But it raises the possibility that, as this population migrates south and possibly forages into Northeast Channel, some individuals might migrate into Georges Basin and Jordan Basin in the Gulf of Maine. The North Dennis and Beverley Farms Massachusetts, and Newport, Rhode Island whales (no. 7–9) probably represent the southern end of the migration of the concentration of whales centered in The Gully.

Rate of deposition of growth layers — Christensen (1973, p. 333–334) has assumed that the increment of growth observed in the last dentinal lamina being deposited, expressed as a percentage of earlier lamina thickness in an older sample of animals, represents growth in May–June, the only time when the whales were captured and sampled. If this is true, then growth slows considerably after July and there is little or no growth in winter. However, unless monthly growth lines are identified (as possibly in Sirenia; Scheffer 1970), or the sample is analyzed by date of kill, we know only that the mean increment of 76% occurred since the previous spring (previous to May–June sampling period). Christensen's data (1973, fig. 4) shows that in the period of time represented by his sample, e.g. the catching period May–June, the approximately 60–90% portion (depending on the individual) of the current growth layer is being deposited. The data do not, contrary to Christensen's interpretation, indicate that 60–90% (mean 76%) of the total growth layer is deposited during the period of the sample. Considering that the scatter in his fig. 4 is of much uniformity, and unless the time of capture is taken account of in the scatter plot, the conclusion is that only 30% of the total deposition of a growth layer (i.e. between approximately 60 and 90%) is being deposited during the period of the fishery. This still does not preclude the possibility of deposition of one growth layer per annum (Christensen 1973; and references cited), particularly in view of our Bay of Fundy specimen having, by our interpretation, completed deposition of the wide, translucent lamina by October. This is assuming that the Bay of Fundy animal is from a population that follows the same migratory schedule as the population(s) sampled by Christensen.

Speculation on function of maxillary crests — The function of the maxillary crests is unknown. Norris (1964, p. 325) has speculated that the maxillary crests in *Hyperoodon ampullatus* (1964, figs. 1–3) "must effectively divide the nasal sac system and melon into one medial and two lateral portions." Norris further proposed that these maxillary crests might enhance a partitioned sound field (1964, p. 327), with highly directional components. Experimental evidence for such a function of topographic features in delphinid skulls (Evans et al. 1964) led Herald et al. (1969) to "suspect that the *Platanista* maxillary flanges act as acoustic baffles to direct the sonic pulses into a narrow beam." We suggest that the maxillary crests of *Hyperoodon* might similarly function as acoustic baffles to deflect the sound, perhaps into a wave guide. In old males especially, the maxillary crests become so massive that the space between them is limited to a vertical slit with parallel walls, which are approximately the same distance apart as are the dorsal edges of the premaxillary bones (e.g. Gray 1882, figs 6–9; see our Fig. 7). This serves to define a tube or conduit which may serve as a sound channel, parallel to and above the mesorostral cartilage. It also narrowly defines a plane, running vertically between the premaxillaries and the dorsointernal edges of the maxillary crests, that might aid in defining a transversely narrow sound field that is also expanded vertically and anteriorally in the sagittal plane. A similar configuration is found in *Platanista gangetica*, and we suggest that if *H. ampullatus* acoustically relates to a surface such as the sea bottom, it may side swim like *P. gangetica* to utilize a side-scan mode of searching.

"Besides these pelagic [cuttlefish and herrings] *Hyperoodon* searches for food at the very bottom of the ocean as proved by the discovery of sea-

FIG. 7. Anterodorsal view of skull of adult, presumably male, *Hyperoodon ampullatus*, showing great enlargement of maxillary crests. (Specimen 1845.7.4.1 in British Museum (Natural History), type specimen of *Hyperoodon latifrons* Gray 1846, and *H. latifrons* the type species of *Lagenocetus* Gray 1863; not no. 1378c, p. 148, Hershkovitz 1966.)

stars in its stomach. Sometimes I have observed a thin yellow covering of lime upon the beak from its rummagings in the muddy ground of the sea." (Ohlin 1893, p. 9).

Also, in light of some recent evidence that the side of the upper lip, e.g. the melon area, is sensitive to incoming sound, the maxillary crests in *Platanista* and *Hyperoodon* may shield incoming or ambient sound from the region of presumed sound generation. The crests also may serve to guide and focus outgoing signals, in a narrow, dorsoanterior plane.

Whatever the acoustic function of the maxillary crests in *Hyperoodon*, it is possible that large bulls perform some specialized foraging or searching role in the social interactions of the pod. This hypothesis is based on the age enhanced sexual dimorphism in the maxillary crests, assuming that development of the maxillary crest and the melon (or spermaceti organ?, see Southwell 1883, p. 481; Flower 1882, p. 726) accompany the external changes observed and described by Gray (1882) and Ohlin (1893). There may be sexual differences in the structure of the melon:

> "In the female, in front of the bones of the head there is a cavity containing a small quantity of oil which is quite colorless and twice the density of that rendered from the blubber. In the males, instead of oil there is a solid lump of fat similar in shape to, and about twice the size of, a large water-melon" (Gray 1882, p. 730).

It could also be that an analogue (or homologue?) of the *Physeter* spermaceti organ (see Norris and Harvey 1972) lies between the maxillary crests in males:

> "In the region of the boss-like protuberance above the beak [the blubber] was 2¼ inches thick; but subjacent to the blubber was a mass of much softer yellow fat, about 9 inches thick, out of which the oil could easily be squeezed. When this was cut through, the space between the maxillary ridges of the skull was opened into, and from it a quantity of almost pure yellow oil flowed. Immediately in front of the blowhole and nasal passages the sub-cutaneous tissue consisted of a thick and dense fibrous layer, in which some fat was infiltrated" (Turner 1886, p. 36–37).

Additional features include the larger size of the males, a possible harem structure (Gray 1882), and sexual dimorphism in teeth (Moore 1968; Christensen 1973). The same may also apply to Cuvier's beaked whale, *Ziphius cavirostris*, in which there appears to be similar sexual dimorphism. In old males, the mesorostral ossification first fills in the mesorostral canal (Fraser 1942), then the posterior end of the ossification is progressively resorbed in a major "basining" effect, which may be related to a sinking downward or enlargement in the skull of part of the air sac system or the melon, or both. This would have the result of increasing the height of the surrounding bones, effectively functioning as a sound baffle or shield, as we speculate the maxillary crests might do in *Hyperoodon*. Selection in *Ziphius* might have been for a narrow sound beam.

Hyperoodon and *Ziphius* might have evolved complicated systems for focusing acoustic signals in an evolutionary divergence through development of different structures performing diverse functions. This view is reinforced in that both are of similar size, school in small pods, and are mainly allopatric. They differ in that the extreme specializations of the skull presumably associated with acoustic capabilities are present in both sexes

in *Hyperoodon* (but more emphasized in aged males), but apparently only in the male in *Ziphius*.

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The Narwhal, *Monodon monoceros*, in Eastern Canadian Waters[1]

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MANSFIELD, A. W., T. G. SMITH, AND B. BECK. 1975. The narwhal, *Monodon monoceros*, in eastern Canadian waters. J. Fish. Res. Board Can. 32: 1041–1046.

In the Pond Inlet area of Baffin Island in 1963–65, 62 narwhals (*Monodon monoceros*) were caught in nets and examined. Growth layers occur in both the extruded tusk and in the embedded tooth. The few identifiable food remains in stomachs were of squid and Arctic cod. At birth, the calf measures about 160 cm in length and weighs just over 80 kg. Fully grown females attain a length of 400 cm and a weight of 900 kg. Males reach 470 cm and a weight of 1600 kg. Calving is assumed to occur about once in 3 yr. A conservative estimate for the narwhal population of Canada and northwestern Greenland is approximately 10,000. Although the birth rate is unknown, it is assumed to be similar to that calculated for the closely related white whale; that is, about 9%. The maximum potential annual catch, based on the highest reported Canadian catch of 442 narwhals in 1957, combined with the Greenland catch of 135 and an assumed sinking loss of 50%, is about 1154. This is above the estimated annual production of 900.

MANSFIELD, A. W., T. G. SMITH, AND B. BECK. 1975. The narwhal, *Monodon monoceros*, in eastern Canadian waters. J. Fish. Res. Board Can. 32: 1041–1046.

Soixante-deux narvals (*Monodon monoceros*) furent capturés dans la région de Pond Inlet, île Baffin, en 1963–65 et examinés. Des couches de croissance sont visibles tant dans la dent en saillie que dans la dent enrobée. Les quelques restes de nourriture identifiables dans l'estomac sont ceux d'encornets et de saidas. A la naissance, le veau mesure environ 160 cm de longueur et pèse un peu plus de 80 kg. Les femelles à la fin de la croissance atteignent une longueur de 400 cm et un poids de 1600 kg. On présume que la mise bas a lieu environ une fois par trois ans. Une estimation conservatrice de la population du Canada et du nord-ouest du Groenland est d'environ 10,000. Bien qu'on ignore le taux de natalité, on présume qu'il est semblable à celui qui a été calculé pour l'espèce proche parente, le béluga, c'est-à-dire environ 9%. La prise annuelle potentielle maximale, fondée sur la plus haute prise canadienne de 442 narvals signalée en 1957, combinée à celle de 135 pour le Groenland, et sur une perte par submersion estimée à 50%, est d'environ 1154. Ceci dépasse la production annuelle estimée à 900.

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IN the summers of 1963, 1964, and 1965 field studies on the narwhal were carried out in the Pond Inlet area of northern Baffin Island. Sixty-two narwhals were examined, most of which were captured in nylon nets 91.4 m (100 yards) long and of 356-mm or 457-mm (14- or 18-inches) stretched mesh. These were set at strategic points in Koluktoo Bay, 161.4 km (100 miles) southwest of the settlement at Pond Inlet, and were tended as regularly as weather and ice conditions permitted.

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External Characteristics

Like its close relative the white whale (*Delphinapterus leucas*), the narwhal shows marked color changes with age. At birth the skin is slate grey, but as the animal grows older patches of white appear about the anus and genital slit and gradually extend up the flanks. At maturity the body becomes almost completely white ventrally and black dorsally with a variegated pattern of dark and light patches on the sides of the body and upper surface of the flukes. The contrast in dorsal and ventral coloration is most pronounced in old males (Fig. 1).

The narwhal's name means "corpse whale" in Norwegian and refers to the presumed likeness of its mottled skin to that of a drowned man. By far the most conspicuous feature of the narwhal is the long tapering tusk, from which the scientific

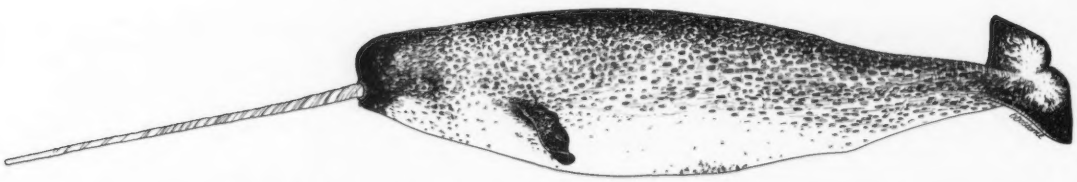

FIG. 1. Adult male narwhal (*Monodon monoceros*) (Drawing, modified from *Nature Canada*, 1973, by Mrs. B. Osborne in collaboration with E. Mitchell.)

name *Monodon monoceros* is derived. In embryos two pairs of teeth develop on each side of the upper jaw. The posterior ones remain rudimentary and eventually disappear (Eales 1950; Fraser 1938). In the adult male the left anterior tooth develops into the tusk, which appears rarely to exceed 200 cm in external length. The right anterior tooth, which measures about 20 cm in length, normally remains embedded in the skull but sometimes develops into a tusk. In females the two anterior teeth develop in the same way as the right anterior tooth of the male. Usually they remain embedded in the skull, but sometimes the left one develops into a tusk, and occasionally both. Two-tusked narwhals are very rare in nature, but their skulls are usually more common in museum collections than the normal form. The tusk appears to be a secondary sexual character which may play a part in aggressive male display. Tusks are probably not used in feeding since the females manage perfectly well without them, but they are invariably worn smooth at the tip. It seems most likely that such wear results from the tusk inadvertently furrowing the bottom when the narwhal is pursuing some of its prey, particularly shrimp and flatfish.

Distribution and Seasonal Movements

In Canada narwhals occur regularly on the east coast of Ellesmere I., in Jones and Lancaster sounds, in Prince Regent Inlet, Navy Board Inlet, and Pond Inlet, at Clyde River on the east Baffin coast, and at Repulse Bay in northern Hudson Bay. They also occur occasionally in Cumberland Sound and Frobisher Bay, at Lake Harbour and Cape Dorset in Hudson Strait, at Coral Harbour, Southampton Island, and at Igloolik in northern Foxe Basin (Fig. 2).

Narwhals are deep water cetaceans. They probably spend the winter in open water in Baffin Bay, especially in the "North Water" which occasionally extends northwards into Smith Sound.

One published winter record is from the account of the North Polar Expedition during the southward drift of the U.S. *Polaris* from northern

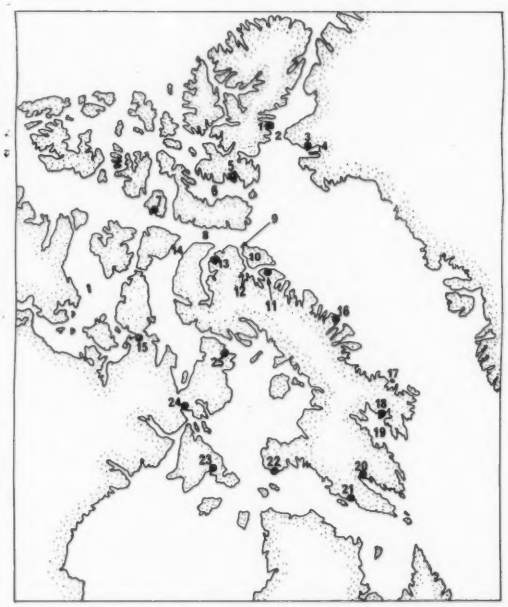

FIG. 2. Distribution of the narwhal in Canada and northwestern Greenland. Numbers refer to the following place names mentioned in the text: (1) *Alexandra Fiord*; (2) *Smith Sound*; (3) *Thule*; (4) Inglefield Bay; (5) Grise Fiord; (6) Jones Sound; (7) Resolute; (8) Lancaster Sound; (9) Navy Board Inlet; (10) Bylot Island; (11) Pond Inlet; (12) Koluktoo Bay; (13) Arctic Bay; (14) Prince Regent Inlet; (15) Spence Bay; (16) Clyde River; (17) Broughton Island; (18) Pangnirtung; (19) Cumberland Sound; (20) Frobisher Bay; (21) Lake Harbour; (22) Cape Dorset; (23) Coral Harbour; (24) Repulse Bay; (25) Igloolik.

Baffin Bay to the Labrador Sea (Davis 1876). Narwhals were seen in the first half of February as the ship drifted south of 68° 50′ N, and then on March 14 and 15 in latitude 64° 32′ N opposite the mouth of Cumberland Sound.

In June and July, as the ice begins to break up, narwhals move along the cracks and shore leads into Pond Inlet, Lancaster Sound, Jones

Sound, and Inglefield Bay in northwestern Greenland. By late July and early August they are found at the heads of certain fiords and bays which they frequent year after year.

Population Status and Catch

No extensive aerial surveys have been made, but a count of animals passing northern Bylot Island in the summer of 1957 indicated a minimum population of 6000 (Tuck 1957). About another 2500 animals are estimated for the Thule area of northwestern Greenland (Bruemmer 1971). Thus a conservative estimate for the total narwhal population of Canada and northwestern Greenland is about 10,000.

Table 1 shows the catch of narwhals reported principally by the Royal Canadian Mounted Police for the period 1953–73. The maximum catch of 442 whales occurred in 1963, while the mean catch for 18 yr of undoubtedly incomplete reporting was 150 whales. These figures tentatively may be doubled to account for sinking losses resulting from the hunting technique of shooting the animal before harpooning it (Bruemmer 1971).

Research Results

Age Determination

The skulls, tusks, and teeth of all netted specimens (Fig. 3) were kept. Well-defined laminae in both the tusks and the embedded teeth appear to be potentially useful in determining the age of the individual animals but a larger sample, possibly obtained from the Inuit (Eskimo) catch, will be required in order to construct life tables from which mortality rates can be derived.

Feeding

Few of the 62 specimens examined contained food. A small number of squid beaks and otoliths from Arctic cod, *Boreogadus saida*, were found in 10 stomachs and small amounts of unidentified fish remains in another three stomachs. No remains of Arctic char, *Salvelinus alpinus*, were found in spite of the extensive runs of this species from the Robertson River which flows into Koluktoo Bay. In northwestern Greenland most narwhals appear to feed on Greenland halibut, *Reinhardtius hippoglossoides*, Arctic cod, and shrimps of several species (Bruemmer 1971; Vibe 1950).

Growth

At birth the narwhal measures about 160 cm in length and weighs just over 80 kg. Fully grown adult females attain a length of 400 cm and weight of 900 kg, and the males a length of 470 cm and weight of 1600 kg. Between 30 and 35% of the body weight is blubber, 25% meat, and 10% skin.

Reproduction

The greater proportion of specimens taken were adult females and their calves. This does not imply an uneven sex ratio in the population, but probably indicates either a bias in catching more naive calves and subsequently their mothers, or a selection of the deep bays at this time of the year by the females with calves. In 1963 two newborn calves with remains of the umbilical cord attached were captured on August 9 and 16, and in 1965 two fetuses measuring 18 and 28 cm were collected on August 19 (Fig. 3). In the Inglefield Bay area of northwestern Greenland three fetuses ranging in length from 25 to 38 cm were also found in females killed in late July and early August and two newborn calves with fresh umbilical scars were killed in early August (Bruemmer 1971).

In spite of the statement by Porsild (1922) that the variation in size of fetuses suggests that a definite rutting season does not exist, the above findings and those of Best and Fisher (1974) indicate that birth occurs about mid-July and conception about mid-April. Assuming a gestation period of 15 mo and a lactation period of about 20 mo, as in the white whale (Sergeant 1973), calving would occur about once in 3 yr.

Narwhals are born when the pregnant females are entering their traditional summering areas in the deep bays and fiords. The newborn calves appear to be adequately protected from the thermal stress of cold water by a 2.5-cm layer of blubber, unlike calves of the white whale that are usually born in the comparatively warm environment of river estuaries (Sergeant 1973).

Although the reproductive rate is unknown, it may be assumed that it is similar to that calculated for the closely related white whale. This appears reasonable since the narwhal has a gestation period of 14.5 mo, similar to that of the white whale, and calving is at approximately the same time of year. Brodie (1971), studying the population of white whales in Cumberland Sound, gave a rate of increase of 0.09, based on the attainment of sexual maturity at 5 yr for females, a 1:1 sex ratio and an age of 21 yr at the last birth. Sergeant (1973), from samples taken in western and northern Hudson Bay, estimated the annual crude birth rate as 0.12. The increase of

TABLE 1. Narwhal (*Monodon monoceros*) catch in the Canadian arctic. Data from R.C.M.P. game reports and other sources. Note that Cape Christian is at Clyde River. Asterisk denotes catch driven in by killer whales. Average for all years 1953–73 (with exception of 1954, 1961, and 1972) = 150.

Area	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Arctic Bay			45		40																150
Alexandra Fiord												1									
Cape Christian				40	40	12	25	54		42	50	25	18	15	24	8	13	9	20		
Broughton Is.																	7				
Cape Dorset					150	35	15							100	73	2		0			
Creswell Bay												4									
Grise Fiord	6	1										20		27	0	7	10	49	25		20
Igloolik	10						0														10
Lake Harbour													1								
Pangnirtung					12	10		35		80–100*	33*			11	1		0	5			0
Pond Inlet	200		65	93	175		52			65	115	60	60	76	40	50					160
Repulse Bay					25								23			0			5		1
Resolute Bay										6	2		0				0				
Spence Bay													6	5	25	2					
Totals	216	1	110	133	442	57	92	89	—	203	200	110	108	234	163	69	30	63	50	—	341

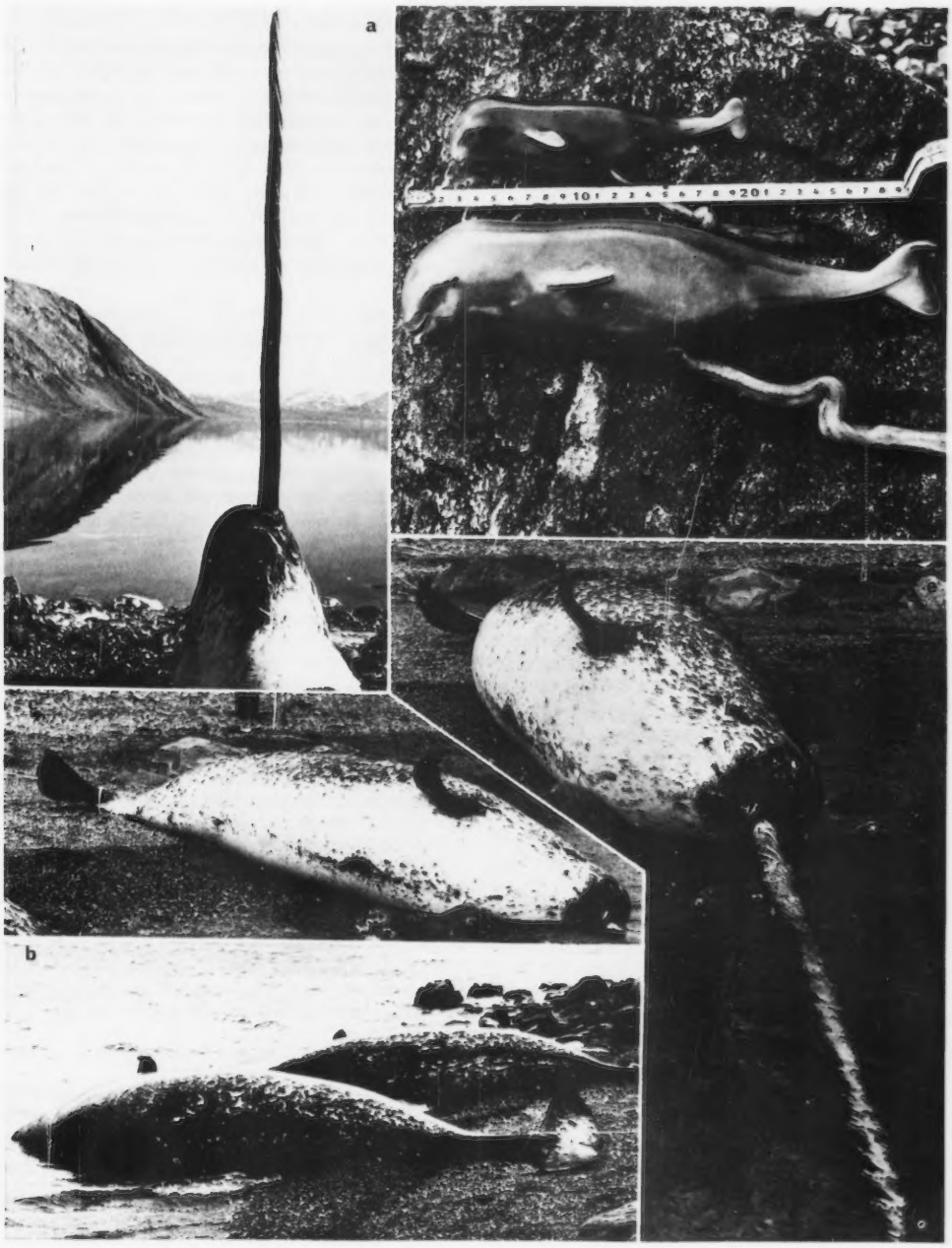

FIG. 3. Narwhals captured at Koluktoo Bay, Baffin Island, N.W.T. a) ventral view of head of adult male, b) dorsal view of adult males, c) ventral view of adult male, d) fetuses taken August 19th, e) anterior view showing dorsal curvature of flipper.

Sergeant's estimate results from a slightly lower age of female sexual maturity (4.5 yr) and the fact that a quarter of the females calve every 2 yr instead of every 3 yr.

Management Considerations

Based on a Canadian and northwestern Greenland herd of 10,000 and a minimum rate of increase of 0.09, the annual production of narwhals is estimated to be about 900. At present we have only very incomplete data on catches. Table 1 shows catches in various arctic communities based on reports from several sources. Although an average figure for the annual catch has been given, it has little meaning because of incomplete reporting. A better figure to use as an indicator of maximum potential catch is the highest catch reported during the years 1953–73; this was 442 in 1957. In addition Bruemmer (1971) estimated the annual catch in northwestern Greenland to lie between 100 and 135 narwhals. Since the hunting techniques used may result in a loss by sinking of as much as 50% of the total kill, the total catch may be doubled to give a maximum kill of about 1154 which is well above the annual production of 900.

The regulations for the protection of narwhals (Canada: PC 1971-120) limit the take of narwhals to five per Inuit hunter. The annual take of this species is usually restricted to four villages; Pond Inlet, Clyde River, Grise Fiord, and Arctic Bay, which had a combined human population in 1972 of 1068. With the demographic structure now prevalent, this population would contain approximately 290–300 males between the ages of 15 and 70. Under the present legislation such a population of hunters could legally kill up to 1500 narwhals. When allowance is made for sinking losses, this could result in a kill more than 3 times the annual production.

Though such a large increase in catch is unlikely in view of the decrease in the number of dogs and the corresponding smaller requirement for whale meat, there is some concern that the high prices paid for ivory may induce the hunters to kill many more males for their tusks.

It must be emphasized that the figures given for maximum catches and production are only rough approximations based on tenuous extrapolations and incomplete data. Clearly catches will have to be monitored carefully and the regulations altered as required. The setting of quotas for each settlement is an appropriate way of handling the problem, and may be instituted in the 1975 hunting season. It is also likely that the export of tusks will be restricted to those bearing an approved tag.

Another important management consideration is the protection of traditional narwhal summer areas from disturbance, either from heavy hunting activity or commercial activities. In the Thule district of northwestern Greenland the Eskimos have themselves forbidden the use of motor boats in the narwhal-hunting areas during the summer months (Bruemmer 1971). A more efficient means of capturing the whales, such as netting, might also be introduced to prevent the high sinking loss.

Future Research

The increasingly intensified search for mineral and hydrocarbon resources in the arctic and their possible large-scale exploitation in the next decade or two have focused attention on the natural resources of the north and the effects that such developments may have on them. The marine mammals, particularly the gregarious species such as the beluga and narwhal, may be particularly susceptible to environmental disturbance, and much more needs to be learned of their general biology, behavior, and distribution. A new, intensified study of the narwhal is being planned by the Arctic Biological Station to commence in 1975, and will be carried out over the next few years.

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Identity, Abundance, and Present Status of Populations of White Whales, *Delphinapterus leucas*, in North America[1]

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White whales, *Delphinapterus leucas*, in the North American arctic number at least 30,000 animals. Largest herds identified are about 10,000 animals in western Hudson Bay, at least as many in Lancaster Sound, and at least 5000 summering in the Beaufort Sea. Hunting in the Canadian arctic has decreased in the last decade from 1000 or more to about 500 annually and is clearly well below sustainable yields except in one locality, Cumberland Sound, where the local population of white whales has never recovered from historic depletion. The species is most vulnerable when concentrated in river estuaries in summer, probably for reproduction. The species' range has shrunk in the St. Lawrence estuary, a change that can be associated with hydroelectric developments in the last decade. The effects of oil exploration, drilling, and island building in shallow water in the Mackenzie Delta are under study, and developments in oil and gas could have an influence on other populations in the Canadian arctic. Tourism related to this species is increasing, without undue disturbance to date.

SERGEANT, D. E., AND P. F. BRODIE. 1975. Identity, abundance, and present status of populations of white whales, *Delphinapterus leucas*, in North America. J. Fish. Res. Board Can. 32: 1047–1054.

Dans l'Arctique nord-américain, les bélugas, *Delphinapterus leucas*, se chifrent par au moins 30,000 individus. Les plus grands troupeaux identifiés sont d'environ 10,000 animaux dans la baie d'Hudson occidentale, d'au moins autant dans le détroit de Lancaster et d'un minimum de 5000 passant l'été dans la mer de Beaufort. La chasse a diminué dans l'Arctique canadien durant la dernière décennie: les captures ont passé de 1000 à 500 individus annuellement et sont nettement inférieures aux rendements soutenus, sauf dans une localité, le détroit de Cumberland, où la population locale de bélugas ne s'est jamais rétablie de l'épuisement qu'elle a subi au cours des ans. L'espèce est le plus vulnérable lorsqu'elle se rassemble dans les estuaires en été, probablement pour se reproduire. Son aire de répartition s'est rétrécie dans l'estuaire du Saint-Laurent, changement qui peut être associé aux développements hydro-électriques de la dernière décennie. Les effets d'explorations pétrolières, forages et construction d'îles dans les eaux peu profondes du delta du Mackenzie sont à l'étude, et des développements dans l'exploitation du pétrole et du gaz pourraient avoir une influence sur les autres populations de l'Arctique canadien. Le tourisme axé sur cette espèce prend de l'importance, jusqu'ici sans dérangement indu.

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THE white whale, *Delphinapterus leucas*, is well known as a large arctic porpoise, unrelated to the true Delphinidae and with one living close relative, the narwhal, *Monodon monoceros*. Arctic adaptations of both include absence of a dorsal fin, a thick dermis, and very thick blubber. The white whale, but not the narwhal, is now believed to use the warm water of river estuaries for calving (Sergeant and Brodie 1969b; Addison and Brodie 1973; Sergeant 1973).

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Identity of North American Populations

Sergeant and Brodie (1969a) tagged white whales in western Hudson Bay by means of tuna

tags and obtained enough returns to demonstrate a movement to northwest Hudson Bay. Sergeant (1973) from tagging returns, sightings, and probable locations of floe-lead in this area believed that this population did not migrate out of the bay. Locations of widest floe-leads can now be seen from ERTS satellite photographs. They are most extensive and permanent in Roes Welcome Sound in the northwest corner of the Bay where autumn recoveries of tagged white whales occurred. The probability is therefore strengthened that white whales winter in the area. Tags placed in white whales in other areas were too few to give returns.

Other evidence of population identity, summarized in Sergeant and Brodie (1969b), comes from an analysis of the length-distribution of animals sampled in different areas. Adult male white whales were found to vary in weight by a factor of three. Large white whales occurred at the southern limits of the range where feeding appeared optimal. Further spread southward was therefore believed to be limited by interspecific competition, presumably with modern Delphinidae. Estuarine populations, such as that occurring in western Hudson Bay, had the smallest animals but could be numerous, presumably because of absence of competitors or predators. This kind of evidence is limited in that populations with equal-sized animals cannot be separated. Analysis shows medium-sized animals in most of the North American arctic and in the St. Lawrence estuary, only western Hudson Bay having small animals and Lancaster Sound and west Greenland (of adjacent waters) large animals.[2]

Direct evidence of the possibility of emigration from the Arctic to the apparently isolated St. Lawrence population came in the cold season of 1972. Mercer (1973) gives details of an isolated animal that lived through spring to fall of 1972 at the head of an inlet in Bonavista Bay, Nfld. (48°42′N, 64°07′W). A second animal, which could, however, have come from the St. Lawrence, lived for some time the same spring in Buzzards Bay, Mass., USA (*Herald-Traveler*, Boston, July 4, 1972). Sergeant et al. (1970) give evidence that occasional animals emigrate from the St. Lawrence population in spring, the season of coldest water and most ice, traveling via the Gaspé Current to Prince Edward Island, Nova Scotia, and the Bay of Fundy. The species is clearly coastal living and the size difference between animals in western Baffin Island (Brodie 1971) and west Greenland (Degerbøl and Nielsen 1930) albeit observed in different decades, suggests that animals do not cross directly the deep Davis Strait.

[2]Brodie (1975) suggests that body size is, further, inversely related to the length of the feeding season.

Abundance

Sergeant (1973) assessed the population along the coasts of western Hudson Bay between 56° and 61°N. Lat. in July 1965 (Fig. 1a) to be near 10,000 animals. Census is facilitated in summer since most animals are in river mouths. More animals inhabit James Bay (Jonkel 1969). The numbers of these, and of white whales inhabiting eastern Hudson Bay, have not been assessed, but are probably less. In Ungava Bay up to 1000 animals have been seen at one time. There are few white whales on the Labrador coast. In the St. Lawrence estuary (Fig. 1b) three surveys were made by the author and W. Hoek in May, July, and September, 1973. Numbers were surprisingly few, estimated at between 500 and 1000, and the distribution was limited to a 50-km length of the estuary, centred at 48°05′N, 69°40′W on the reefs around the Saguenay River, the best known locality for the species in Canada (Howell 1935; Sergeant and Hoek 1973). Mitchell (1974) gave a cumulative catch estimate of the population as 5000 or less. Hunting ceased about 1940 (see Vladykov 1944, p. 148). It seems, therefore, that the species has declined in the St. Lawrence to an unknown but considerable degree.

In the eastern Beaufort Sea in July 1973 (Fig. 1c) Sergeant and Hoek (1974a) estimated some 4500 animals concentrated in the estuary of the Mackenzie River, 68°40′N, 135°W, presumably for calving. About 5000 were estimated here in July 1974 (Sergeant and Hoek 1974b). These figures were higher than any previous estimates (Addison and Brodie 1973) and may represent near real totals since particularly heavy pack blocked the coast eastward in 1974, which would have reduced chances of calving in rivers around Banks Island and concentrated animals in towards the warm Mackenzie River water. Permanent pack probably blocks the animals in the Beaufort Sea from those occurring further east, white whales being reported only very rarely, at Coppermine (67°49′N, 115°05′W). As discussed in Sergeant and Hoek (1974a), the Beaufort Sea animals migrate east into the area from along the north Alaskan coast in May and June, and depart west again in September, a rather long migration for the species forced on them by unfavorable winter ice conditions.

In this connection the role of Liverpool Bay

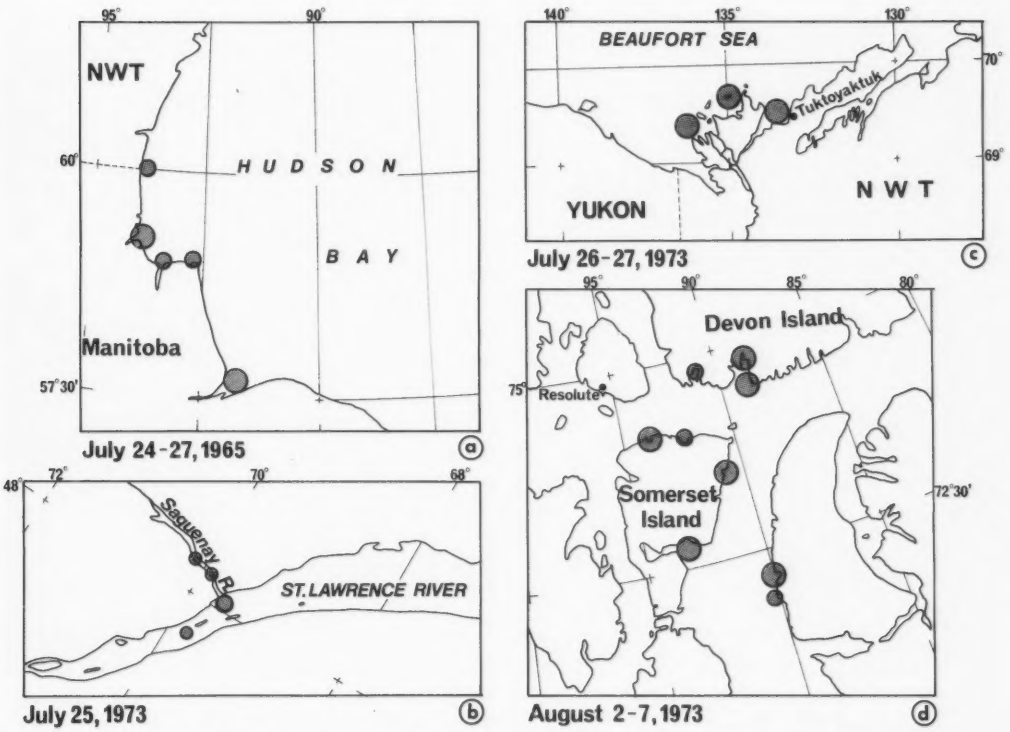

FIG. 1. Portions of Canadian arctic and St. Lawrence River, showing localities mentioned in the text. Three sizes of circles give magnitude of summer concentrations of white whales (*Delphinapterus leucas*) from 10s through 100s to 1000s.

(70°N, 130°W) is interesting. This bay leads WSW to a series of brackish lakes, the Eskimo Lakes. On at least one occasion white whales failed to survive the winter when restricted to the Eskimo Lakes by sea ice, in October 1966 – January 1967 (Sergeant and Hoek 1974a). In July 1974, Mr J. Lovrity of the Arctic Biological Station found a single carcass in Liverpool Bay that could have been an animal that had remained and died the previous autumn or one that had arrived too early in summer and been crushed. The system is evidently a natural, funnel-shaped trap that tends to attract white whales to remain in an area where overwintering is not possible.

In Lancaster Sound (74°10′N, 85°00′W) (Fig. 1d) white whales are numerous and large (Sergeant and Brodie 1969b) implying seasonally favorable oceanographical conditions. In fact, recent ERTS satellite pictures show extensive open water or very loose pack through the main Lancaster Sound in March and April 1974, which suggest that this is the normal winter pattern. Wintering of white whales and other sea mammals could well occur making migrations necessary only on a local scale. Incomplete surveys by Sergeant and by Mr J. D. Heyland of the Quebec Wildlife Service showed at least 10,000 animals at river mouths and bays in early August 1973. Personnel of the Arctic Biological Station in July and August 1974 studied one such concentration at the mouth of Cunningham Inlet, northern Somerset Island (Fig. 2) where over 1000 white whales congregate. As elsewhere, such concentrations are related to mouths of rivers flowing off lowland and with relatively warm temperatures, here up to 10 C. The period of concentration is associated with the presence of newborn calves, although calving has not been seen to take place. Other more temporary concentrations in bays when the ice is rotting out of them seem to be temporary, and probably represent "raids" on aggregations of schooling fish.

In upper Cumberland Sound, Baffin Island, Brodie (1971) found a population of only some

FIG. 2. A concentration of white whales, believed to be calving animals, at Cunningham Inlet, Somerset Island, August 6, 1973 (photo by D. E. Sergeant). Several females can be seen nursing newborn.

750 animals in his 1967 aerial census and gave reasons for suspecting a long-continued decline. Sergeant observed a river mouth here, unoccupied by white whales in the summer of 1971, although it resembled another river mouth that the whales observed by Brodie (1971) used for calving. It was closer to the main Eskimo settlement of Pangnirtung than Brodie's study area so excessive hunting or boat traffic may have eliminated whales from this river mouth.

A summary of estimates of numbers in the Canadian arctic is given in Table 1.

In Alaska, there are estimated to be 150–300 white whales in Cook Inlet and 1000–1500 in Bristol Bay, with unknown but greater numbers northward. The annual harvest off Alaska is estimated at 150–300 (Anon. 1973). Around Bristol Bay white whales are a nuisance to salmon fisheries (Fish and Vania 1971) but are scarcely harvested. Johnson et al. (1966) imply that few white whales remain on the north Alaskan coast after migrating east towards the Mackenzie Delta or perhaps offshore, in summer. Fay (1974) states that small numbers remain in summer in

TABLE 1. Maximal numbers of white whales (*Delphinapterus leucas*) observed in the late 1960s – early 1970s, Canadian arctic.

Area	Number	Observer
Western Hudson Bay	10,000	Sergeant (1973)
Ungava Bay	1,000	Unpublished data
St. Lawrence	500	Sergeant and Hoek (unpublished data)
Mackenzie R. Delta	4,000	Sergeant and Hoek (1974)
Lancaster Sound	10,000	Sergeant (unpublished data)
Cumberland Sound, Baffin Is.	750	Brodie (1971)
Total counted	26,500	

Norton Sound and the Yukon Delta, and that others pass west into the Chukchi and East Siberian seas.

Present Status

The Scottish whalers after their decimation of the Greenland whales (*Balaena mysticetus*) of Davis Strait, Baffin Island, and Lancaster Sound, turned their attentions to white whales and other smaller fry. They drove white whales in to shore in such inlets as Elwin Bay, Somerset Island (73°32′N, 90°51′W) (Lubbock 1937). The populations of white whales here were not, however, permanently reduced since in early August 1973 Sergeant found about 800 white whales in Elwin Bay. There are no Eskimo settlements in the area.

The situation is different in Clearwater Fjord, upper Cumberland Sound, Baffin Island (Brodie 1971). Here the driving-in technique persisted into the late 1920s, and Eskimo hunting has continued up to date, being now limited by a quota. The original population of white whales has steadily diminished. This fact argues a low rate of migration of white whales from Lancaster to Cumberland Sound, in spite of a current setting southward along eastern Baffin Island between the two areas, and a relatively high catch rate in Cumberland Sound.

Catches through the 1950s and 1960s averaged about 1000 white whales through the whole Canadian arctic (Table 2), over half being taken in western Hudson Bay. The former commercial fishery at Churchill (Sergeant 1968) was the only one of its kind, being dependent on a rail link which allowed sale of minced, frozen carcasses to mink (*Mustela vison*) ranches in the Prairie Provinces. The operation was marginal, principally because of a season lasting only 6 wk, allowing a catch of 400–600 animals annually.

By 1965 the whaling station at Churchill though well designed, was falling into disrepair. A fishery began in 1961 at Whale Cove, Northwest Territories using nets. Meat and muktuk (the thick dermis with some subcutaneous fat) were frozen or canned for human consumption, chiefly in other Eskimo settlements. However, such fisheries were doomed in 1970 by the discovery of mercury levels in white whale meat in excess of the level, 0.5 ppm wet weight, presently allowable for human consumption. This may well

TABLE 2. Canadian white whale catch statistics.

	Zone				
Year	1 Western Arctic	2 Eastern Arctic	3 Hudson and James bays	4 St. Lawrence River	Total
1951		292	591	No data	883[a]
1952		204	788	available,	992
1953		285	681	catches	966
1954	210	201	616	small and	1027
1955		232	557	irregular	789
1956		138	476		614
1957		199	844		1043
1958		279	550		829
1959	54	487	302		843
1960	145	308	510		963
1961	145		103		248
1962	96	172	392		660
1963	94	133	560		787
1964	30	109	727		866
1965	30	38	701		769
1966	50	69	814		933
1967	40	214	507		761
1968	14	56	652		722
1969		27	328		355
1970		85	326		411
1971			13		13[a]
1972	120	61			181[a]
1973	297	63	178		538

[a]Data incomplete.

be of natural origin, but comparisons of levels of mercury in different populations of white whales have not yet been achieved. A sport fishery followed at Churchill but proved of little economic value to the Cree and Chipewyan hunters, and was banned in 1973 for humane reasons. Some animals have been taken for oceanaria from Churchill and the neighboring Seal River (Gewalt 1970), from the St. Lawrence estuary, and from Bristol Bay, Alaska (Ray 1961). Eskimo fisheries continue but the catch has dropped to about 500 per annum in arctic Canada (Table 2). There is probably nutritional merit in the continued use of fresh or frozen (but not sun-dried or canned) muktuk, which is rich in vitamin C (Rodahl 1949), and has low mercury levels.

Growth and Production

The white whale is a slow-growing animal. Mandibular growth layers are believed to be annual (Brodie 1969) and dental layers biennial (Brodie 1969; Sergeant 1973) although direct proof is still lacking. On this basis, extreme ages reached are 25–30 yr. Sustainable yield is believed to be between 0.05 and 0.10 per annum, production being some 0.14 per annum in western Hudson bay. On this basis a kill averaging between 500 and 1000 animals out of 10 000 is within permissible limits. Long-term catches of about 500 white whales at Churchill, biased towards a catch of 66% males, had no effect on populations over decades.

Effects of Man

In the St. Lawrence three aerial surveys in May, July, and September 1973 showed that white whales only penetrated up the Saguenay River in July. Previous opinion is therefore strengthened that the species calves in mouths of small streams entering the Saguenay fjord. Further east, on the Manicouagan Bank, we found no white whales, where they had been collected frequently for the study of Vladykov (1944), and we believe that the damming of the Manicouagan and Outardes rivers for hydroelectric power has altered the heat budget sufficiently to have eliminated calving here.

This belief is reinforced by observations of Dr H. Neu of the Bedford Institute of Oceanography who reports that in 1965, during the start of construction on the Manicouagan River, the peak water flow in May was 3000 m^3/s. In 1970 the peak flow in May was 500 m^3/s. The mean monthly outflow is now about 17% of the original. The peak calving of white whales in the St. Lawrence River system is probably in late May (Vladykov 1944).

White whales are capable of swimming in very shallow water and, typically, move in over tidal flats where water temperatures exceed 12 C, even in the arctic (Brodie 1975).

Dr Neu also suggests that the surface temperature in the central Manicouagan–Outardes estuary may now be reduced from 6 to 7 C before damming to the usual subsurface St. Lawrence temperature of 2–3 C in May.

In responding to peak electrical demands, power stations may adjust water flow several times daily. Thus, the effect on the heat budget of reduced mean outflow is further compounded by rapid daily fluctuations. Water temperatures may either be too low or unreliable for calving of white whales. White whales are still recorded from this area in winter when they spread down the estuary of the St. Lawrence seawards.

In Manitoba, the Nelson River will soon be dammed but water will be added by impounding the upper Churchill River, increasing the net outflow of the Nelson River. Presumably the outflow will be spread out longer through the year and might be diminished somewhat in spring. What effect this alteration will have on the 5000 or so white whales that congregate in the Nelson River (Sergeant 1973) is uncertain. The white whales of the Churchill River have already been reduced historically by trading, hunting, and port development, in all probability, to 1000 or less (Sergeant 1973), so that reduction of flow in the Churchill river will merely exacerbate a long-continued decline. The small Seal River, 50 km northwest of the Churchill River (Fig. 1a), harbors some 1500 white whales in its estuary in summer, the second most important calving concentration in western Hudson Bay after the Nelson River. A small amount of hunting by canoe from Churchill, and of tourism, mostly by air, have reached this population. It should surely be left alone and the Seal River left as a "wild river." Although accessible from Churchill the estuary is full of boulders and requires local knowledge. Visitors can see white whales well at the Churchill River estuary especially from old Fort Churchill, a national historic park.

In the central part of the Mackenzie Delta, oil companies are creating artificial islands in shallow water (Fig. 3). The accompanying noise, boat and air traffic must frighten white whales to some distance, yet such disturbance probably does not yet exceed that caused by Inuit (Eskimo) hunting. Hunting takes place throughout but mainly in the eastern part of the Delta and about 150 white whales are taken annually with others wounded

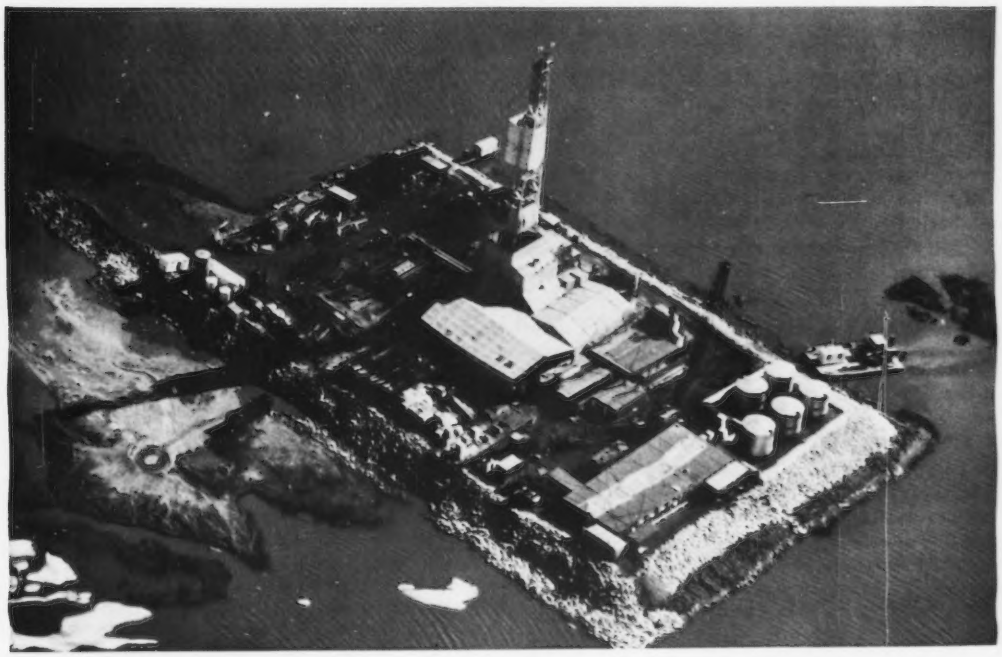

FIG. 3. Artificial Island (Sun Oil Ltd.), near Pullen Island, Mackenzie Delta (photo by W. Hoek, July 1974). These islands pose a new kind of disturbance in the general area of white whale calving grounds.

and lost. However, oil developments are increasing rapidly with the building of more artificial islands in the central part of the Delta. So far, there is little overall disturbance in the western part of the Delta and there is no evidence of any decline in the numbers of white whales entering the estuary, probably for calving as elsewhere. (However, calving here is hard to observe because of the very muddy water of the estuary.) Therefore, prudence needs to prevail in island-building, and all types of harassment kept to a minimum.

In Lancaster Sound, one proposed route for a gas pipeline crosses from Resolute Bay, Cornwallis Island to Cunningham Inlet, Somerset Island. In this inlet some 1500 white whales gather to calve annually (Fig. 2). Construction of a pipeline, and even operating noise made by compressors, could disturb herds to another site, and such sites seem limited, since they depend on streams with warm water, flowing off lowland.

It is still too early to tell how important "viewing" of white whales will become in arctic Canada. It is now well developed in the St. Lawrence estuary out of Tadoussac. Calving concentrations, as shown in Fig. 2, can be impressive but deserve the least possible disturbance if populations are to be maintained. They offer unique opportunities for observation and behavioral research. This was carried out in summer 1974 in Cunningham Inlet. White whales here seem immune to quiet terrestrial observation but are easily disturbed by waterborne noises, even by a skipped stone, probably because most of their natural predators — killer whales *Orcinus orca* for example — live in the sea. At Cunningham Inlet in 1974 births were not seen in the river mouth, but newborn calves could be seen on the backs of the mothers, as shown in many Eskimo carvings, or suckling.

Feeding concentrations also occur in late summer in the high arctic, as at Maxwell Bay, southern Devon Island (74°37′N, 89°00′W) in early August 1973. The animals appeared to be feeding on concentrations of *Boreogadus saida* in the last disappearing ice, as described previously in northwest Greenland by Vibe (1950). Such concentrations could be vulnerable to development of ports at such localities, with associated pollution and disturbance.

Aesthetics and Ethics

Watching white whales at the Tadoussac ferry

crossing has been a hobby for many years (Howell 1935), but only since 1971 have large numbers of people begun to enjoy watching this species plus the large Cetacea in the estuary of the St. Lawrence (Sergeant and Hoek 1973). Churchill is also an accessible place for viewing white whales and there are probably other such sites. Calving sites need watching but if carefully controlled whale viewing should be considered as a source of revenue to the north, a possible substitute for hunting in areas of diminished whale populations. Probably the main value of hunting is the value of fresh or frozen muktuk as a source of vitamins, especially Vitamin C (Rodahl 1949). Consumption of frozen muktuk in the arctic could be encouraged, especially in late winter and spring, as a guard against vitamin deficiencies at a time of year when fresh food is in short supply. Well-managed stocks of white whales provide a renewable resource of lipid, protein, and vitamins which has the virtue of traditional acceptability among the Inuit as well as being important in their hunting culture.

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Status and Aspects of the Life History of the Bottlenose Dolphin, *Tursiops truncatus*, in Florida[1,2]

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ODELL, D. K. 1975. Status and aspects of the life history of the bottlenose dolphin, *Tursiops truncatus*, in Florida. J. Fish. Res. Board Can. 32: 1055–1058.

Aerial censuses in waters of the Everglades National Park, Florida every 1–2 mo between September 1973 and August 1974 resulted in sightings of a minimum of five, a maximum of 79, bottlenose dolphins. Seasonal variation in numbers apparently occurs.

ODELL, D. K. 1975. Status and aspects of the life history of the bottlenose dolphin, *Tursiops truncatus*, in Florida. J. Fish. Res. Board Can. 32: 1055–1058.

Au cours de recensements aériens des eaux du parc national Everglades, Floride, à intervalles de 1–2 mois de septembre 1973 à août 1974, on a compté un minimum de cinq et un maximum de 79 dauphins à gros nez, *Tursiops truncatus*. Les nombres semblent varier avec les saisons.

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THE bottlenose dolphin, *Tursiops truncatus*, is one of the best known small cetaceans because of its wide use in marine shows and aquaria. Because *T. truncatus* is easily captured and maintained in captivity, its behavior and physiology in captivity are particularly well known (e.g. Caldwell and Caldwell 1972a, b; Ridgway 1972; Chapskii and Sokolov 1973) compared to our scant knowledge of other small cetaceans in the same biological areas. Species of genera such as *Globicephala*, *Delphinapterus*, and *Stenella* are better known than *T. truncatus* in other aspects of their life histories (growth, reproduction, and population biology) because large numbers have been taken in specific fisheries (Sergeant 1962, 1973; Brodie 1971, 1972; Kasuya 1972) or incidental to operations in other fisheries as in the case of *Stenella* (Perrin 1969). Information about the life history of *Tursiops* in Florida, particularly reproductive and population biology, is very important when one considers that these waters have been the prime source of the bottlenose dolphins exhibited in the United States and Europe (Caldwell and Caldwell 1972c). The purpose of this paper is to present a brief summary of our knowledge of *Tursiops* which is beginning to parallel that of the California sea lion, *Zalophus californianus*. This pinniped is also used as a performing animal in oceanaria, circuses, and zoos, but very little was known about it until as late as 1965 (Peterson and Bartholomew 1967; Odell 1972), notwithstanding that over 30,000 sea lions could be found on the islands just a few miles off the coast of populous southern California (Odell 1971).

A very similar situation exists with *T. truncatus* on the east coast of North America, particularly off the State of Florida. Observations made during capture operations indicate that there are large numbers of *Tursiops* in the waters of southeast Florida (E. D. Asper personal communication; also see Caldwell and Caldwell 1972c). These areas can be reached by boat and plane making it relatively easy to conduct certain studies on the *Tursiops* population (see Fig. 1).

Life History Parameters

Almost all of the information on the life history of *Tursiops* comes from animals captured at one time or another for display purposes and from stranded animals.

LONGEVITY AND MORTALITY

Sergeant et al. (1972) show from a sample of 62 animals that both sexes may live to about

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974; subsequently revised.

[2]A contribution from the Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Fla. 33149, USA.

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25 yr of age in the wild and that, therefore, the mortality rates appeared to be the same for both sexes. An animal born in captivity lived for 21 yr. S. Ohsumi (personal communication) states that *Tursiops* off the coast of Japan may live for 30–35 yr. I know of no other mortality data for this species.

Sexual Maturation

Males mature at lengths ranging from 245 to 260 cm or 10 to 13 yr of age (Sergeant et al. 1973; Harrison et al. 1972). Females mature at lengths ranging from 220 to 235 cm or 5 to 12 yr of age (Sergeant et al. 1973; Harrison et al. 1972). There is an apparent conflict between the results obtained by these two groups of authors, especially concerning the females. McBride and Kritzler (1951) suggested that females mature at age 4 and have their first calf at age 5. This conflict would probably be resolved if animals born in captivity grow and mature at optimal rates, which seems likely because of high feeding rates in captivity. Almost all of the specimens used for estimation of the age of sexual maturity have come from Florida. S. Ohsumi (personal communication) has indicated that sexual maturity in the female may occur at an age of 6–7 yr in the wild Japanese *Tursiops* population. Females can accumulate as many as one corpus albicans per year after sexual maturity (Sergeant et al. 1973), but this may not indicate the production of one calf per year (Brodie 1972). There is considerable confusion over the proper interpretation of corpora albicantia in cetacean ovaries, and multiple ovulations and accessory corpora lutea confuse the issue (Brodie 1972; Harrison et al. 1972; Sergeant 1973). In addition, care must be taken when comparing animals from different populations.

Calving and Mating

Gestation in *Tursiops* lasts about 12 mo and it has been suggested that the calving interval is 2 yr (McBride and Kritzer 1951; Tavolga and Essapian 1956). Harrison et al. (1972) suggest that ovulation may be induced rather than spontaneous. Most of the calving and mating apparently occurs from February to May in Florida waters, but there is also some evidence for a calving and mating period from September to November in south Florida waters (Essapian 1963). Reported birth lengths are from 98 to 126 cm and weights from 9.1 to 11.4 kg (Gunter 1942; Harrison et al. 1972; Sergeant et al. 1973).

Food Habits

Gunter (1942) examined a small number of stomachs from animals taken in the Gulf of Mexico off the Texas coast. He found 12 species of fish and one shrimp. Mullet (*Mugil* sp.) comprised over 80% of the stomach contents with gizzard shad (*Dorosoma cepedianum*) the next most common fish. Caldwell and Caldwell (1972c) report that *Tursiops* have been known to eat the following organisms: southern stargazer (*Astroscopus y-graecum*), sea catfish (*Galeichthys felis*), croaker and drum (Sciaenidae), herring (Clupeidae), needlefish (Belonidae), eels, and squid. *Tursiops* along the east central coast of Florida reportedly steal king mackerel (*Scomberomorus cavalla*) that have been hooked by commercial fishermen.

Population Biology

Little is known about this aspect of *Tursiops* biology. There may be a seasonal migration along the northeast coast of North America (see Mead, this volume) based on old records from the Cape Hatteras porpoise fishery. Local migrations have been mentioned by Caldwell and Caldwell (1972c), but in general there is little data on which to base sound conclusions.

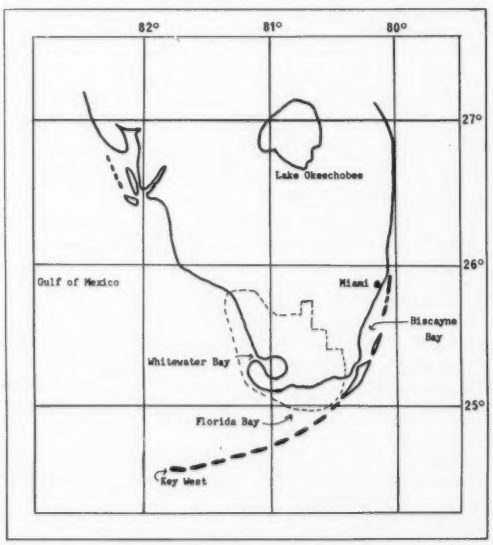

FIG. 1. Portion of South Florida. Dashed lines indicate approximate boundary of the Everglades National Park.

TABLE 1. Censuses of *Tursiops truncatus* in the waters of the Everglades National Park, Fla., USA.

Date	Florida Bay	Whitewater Bay	Gulf of Mexico	Western Inland Waters	Total
Sept. 28, 1973	8	3	0	0	11
Oct. 16, 1973	—	2	3	0	5
Dec. 18, 1973	2	2	18	0	22
Jan. 16, 1974	1	9	0	0	10
Feb. 15, 1974	8	10	15	7	40
Mar. 12, 1974	8	2	38	31	79
May 5, 1974	0	2	9	2	13
May 23, 1974	0	4	2	1	8
June 19, 1974	1	0	14	3	18
Aug. 15, 1974	0	5	16	11	32

Research Results

Flights were made over the waters of Everglades Park, Florida every 1–2 mo between September 1973 and August 1974, using a fixed wing aircraft at an average speed of 110 mph. Each flight lasted 3 h, of which approximately 2½ h were spent carrying out the census.

Preliminary analysis of the census data taken on these monthly flights show a variation of between 5 and 79 bottlenose dolphins sighted (Table 1, Fig. 1). This suggests that there may be a seasonal variation in the number of animals found in Park waters, particularly on the Gulf of Mexico side and the western inland waters. The variation may be even more pronounced on the east coast of Florida in Biscayne Bay and the surrounding waters. The reason for the variation, if its existence is confirmed, could be related to the calving–mating season or to seasonal changes in food distribution or water temperatures. Further analysis and conclusions must await the completion of at least 2 yr of observation.

Discussion

It is obvious that much remains to be learned about the ecology and dynamics of the Florida population of *Tursiops truncatus*, particularly if a live capture fishery is to continue (see Asper, this volume) and if it is to be properly managed to prevent depletion of the stock. Some of the most important data to be obtained are: (1) Determination of the mean age of sexual maturity in females. This is important because collectors prefer young unscarred animals for training and display. If females mature at a late age, it is possible at least in theory to remove all the immatures from a population before they could reproduce, and then cause the extinction of the population. (2) It follows from (1) that the migratory nature of the population and its size must be determined. Is the population composed of relatively small sedentary "subpopulations" or is there a large-scale seasonal migration and intermixing of the herds? Little has been published on individual and population movements in Florida since the observations of Caldwell (1955). (3) It will be necessary to define the calving and mating season(s) in the areas of exploitation to avoid disturbing the animals during these times and thereby causing increased calf mortality and decreased pregnancy rate. (4) Other questions such as the age and sex structure of the herds must also be answered.

Research currently underway in south Florida is directed toward answering these questions about the biology of *T. truncatus* in subtropical Atlantic waters.

Acknowledgments

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Distribution and Differentiation of Populations of Dolphins of the Genus *Stenella* in the Eastern Tropical Pacific[1]

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PERRIN, W. F. 1975. Distribution and differentiation of populations of dolphins of the genus *Stenella* in the eastern tropical Pacific. J. Fish. Res. Board Can. 32: 1059–1067.

There are at least two races of spotted dolphin, *Stenella attenuata*, in the eastern Pacific, based on length, color pattern, and skeletal differences. The coastal form is provisionally called *S. attenuata graffmani*. The offshore form is distinct from a third, Hawaiian race. Likewise, at least three unnamed races of spinner dolphin, *S. longirostris*, occur in the eastern Pacific. Length, shape of adult male, color pattern, and cranial differences are used to distinguish a Costa Rican, an eastern, and a whitebelly race. An Hawaiian race is distinct from these. A distributional break may indicate two stocks of the striped dolphin, *S. coeruleoalba*.

PERRIN, W. F. 1975. Distribution and differentiation of populations of dolphins of the genus *Stenella* in the eastern tropical Pacific. J. Fish. Res. Board Can. 32: 1059–1067.

Il existe au moins deux races de *Stenella attenuata* dans le Pacifique oriental, se distinguant par la longueur, le motif de coloration et le squelette. Nous nommons provisoirement la forme côtière *S. attenuata graffmani*. La forme du large est distincte d'une troisième, la race hawaïenne. Semblablement, au moins trois races sans noms de *S. longirostris* se rencontrent dans le Pacifique oriental. La longueur, la forme des mâles adultes, le motif de coloration et les différences craniennes servent à distinguer une race de Costa Rica, une race orientale et une race à ventre blanc. Une race hawaïenne est différente de celles-ci. Une discontinuité dans la répartition peut indiquer l'existence de deux stocks de *S. coeruleoalba*.

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THE purse seine fishery for tuna in the eastern tropical Pacific employs three species of *Stenella* (Perrin 1968, 1969; NOAA 1972). The purpose of this paper is to describe the distribution of the subpopulations of these three species and the grounds for separating them.

The involved species of dolphin are *Stenella attenuata* (Gray, 1846), called "spotted porpoise" by the American tuna fishermen, *S. longirostris* (Gray, 1828), called "spinner porpoise," and *S. coeruleoalba* (Meyen, 1833), called "streaker porpoise." The taxonomy of the genus is unsettled, and the nomenclature used here is provisional. *Stenella attenuata* is the most important of the three species to the fishery (Table 1). *Stenella longirostris* is next most important. Only a very few net sets are known to have been made on *S. coeruleoalba*. Other cetaceans involved in the fishery are the delphinids *Delphinus delphis* L., *Tursiops* sp., *Lagenodelphis hosei* Fraser, 1956, and *Steno bredanensis* (Lesson, 1828), the latter three to very minor extent.

Materials and Methods

Most of the distribution data and the specimens used for morphological studies were collected by scientific observers aboard commercial tuna seiners during the period 1968–74. I also surveyed available U.S. museum collections and the literature. Complete details concerning the specimens and methods used in the analyses of morphology have been previously presented (Perrin 1972a, 1973).

In tagging dolphins to delineate their ranges and migrations, several tagging methods and types of tags were used. Animals were tagged on the deck after being extricated from the net or separated from the catch of tuna, in the net during the "backing down" rescue operation (Perrin 1969; Coe and Sousa 1972), or as they rode the bow-wave of the vessel. Dart-type spaghetti tags of two types were used. Initially, an all-plastic tag was used (Mather 1963). Since 1971, a tag with a metal dart (Mather 1963) has been used. Animals on the deck or in the net were tagged with a short wand. Bow-riding animals were tagged with a long wand with a quick-release head (Beckett 1968) or with a crossbow (Evans et al. 1972). Some

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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TABLE 1. Observed net sets on delphinids by tuna purse seiners, 1971–74.

Stock	Number of observed net sets (% of year's observed sets in parentheses)			
	1971	1972	1973	1974[a]
Stenella attenuata	64 (94.1)	219 (90.5)	616 (81.5)	681 (84.4)
Coastal race	0	0	7 (1.0)	0
Offshore race	64 (94.1)	219 (90.5)	609 (80.6)	666 (82.5)
Unidentified to race	0	0	0	15 (1.9)
S. longirostris	40 (58.8)	138 (57.0)	311 (41.1)	313 (38.8)
Eastern race	28 (41.1)	70 (28.9)	147 (19.4)	286 (35.4)
Whitebelly race	12 (17.6)	28 (11.6)	43 (5.7)	49 (6.1)
Unidentified to race	11 (16.2)	6 (2.5)	117 (15.5)	1 (0.1)
S. coeruleoalba[b]	0	0	2 (0.3)	2 (0.2)
Delphinus delphis	2 (2.9)	26 (10.7)	97 (12.8)	110 (13.6)
Northern race[c]	0	0	15 (2.0)	0
Southern race[c]	2 (2.9)	26 (10.7)	82 (10.8)	110 (13.6)
Tursiops sp.[b]	3 (4.4)	7 (2.3)	5 (0.7)	34 (4.2)
Lagenodelphis hosei	1 (1.5)	0	0	0
Steno bredanensis	0	0	0	2 (0.2)
Total sets observed[d]	68	242	756	807

[a]Partial data, as of March 25, 1974.
[b]May be more than one stock.
[c]Races *fide* W. E. Evans personal communication.
[d]Do not equal sum of species totals; some sets are on mixed herds.

TABLE 2. Races of *Stenella attenuata* in eastern Pacific and Hawaiian waters. Length data previously unpublished; color pattern and skeleton data from Perrin (1972b). Sample sizes in parentheses.

Race	Adult length (see Fig. 2) (*cm*)		Adult color patterns	Skeleton		
	Males	Females		Adult condylobasal length (*mm*)	Adult tooth diameter (*mm*)	No. vertebrae
Coastal	203–257 (37)	184–227 (76)	Dorsal spotting light to heavy, but medium to heavy in most. Dorso-ventral contrast low.	419–460 (18)	3.4–5.7 (9)	77–79 (9)
Offshore	179–224 (332)	167–206 (1042)	Dorsal spotting light to heavy, but medium to light in most. Far offshore (> 800 km) animals lightly spotted.	356–411 (68)	2.7–4.0 (65)	77–83 (61)
Hawaiian	182–202 (6)	189–203 (3)	Dorsal and ventral spotting so obscure as to appear absent. Adult resembles neonate of offshore race (Perrin 1970).	395–440 (12)	—	79 (2)

plastic dorsal-fin tags (Norris and Pryor 1970) were also used.

Species Accounts

Stenella attenuata — There are at least two races of spotted dolphin in the eastern Pacific. They differ in several features (Table 2). A coastal form is relatively large and robust, has heavy jaws and teeth, is heavily spotted, and is restricted to onshore waters from the Gulf of California to northern Peru (Fig. 1). An offshore race is relatively small and slender, has lightly built jaws and teeth, is spotted to varying degree, and occurs in offshore waters west to about 145°

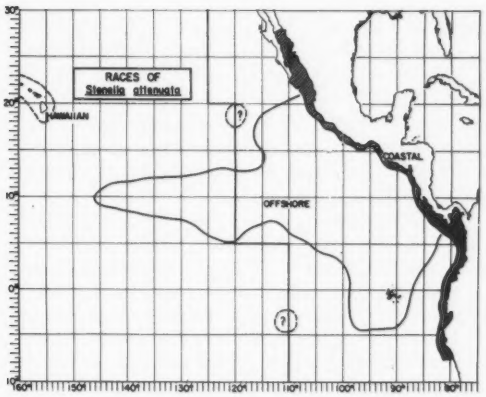

FIG. 1. Known ranges of races of *Stenella attenuata* in the eastern Pacific, based on collections and sightings by National Marine Fisheries Service observers aboard commercial tuna seiners and research vessels, museum collections and literature records. Boundaries are approximate only, and fluctuate seasonally and from year to year.

W long. The ranges of the two forms may overlap, or the boundary between them may move seasonally or from year to year. They have not been observed or captured together. In the central latitudes of the range the coastal form has been collected as far offshore as 50 km and the offshore form as far inshore as 20 km from the coast. The offshore form predominates in the fishery (Table 1). Another race inhabits the waters around Hawaii and may extend into the South Pacific and to the west. This form is also small and slender, but is less spotted.

The existence of two forms was first suspected upon comparison of a large series of skeletal specimens from the tuna fishery with the material available in museums, which consists mostly of animals harpooned on the coast and includes the type of *Stenella graffmani* (Lönnberg, 1934). Both series included obviously very young and very old individuals. The skulls in the coastal series were longer, broader, and had proportionately larger posttemporal fossae and teeth than those in the series from the tuna fishery (Perrin 1972a). The skulls of the two forms differ mainly in those features that have to do with feeding. The coastal form appears to be adapted to feeding on larger, more substantial prey than does the offshore form. The offshore form feeds primarily on epipelagic squids and fishes (Perrin et al. 1973). No data are available on the diet of the coastal form. The two series of specimens are statistically separable on the basis of aspects of the skull related to feeding (Perrin 1972a). The Hawaiian form is also separable on the basis of skull measurements. It has a longer, broader skull than does the offshore form but does not have the more massive feeding apparatus like that of the coastal race. Within the offshore race, an east–west cline may exist. Specimens from farthest west tend to be most Hawaiian-like.

The coastal form also has a larger, more massive postcranial skeleton than does the offshore form and, on the average, fewer vertebrae (Perrin 1972a). The range of vertebral counts for the coastal series is 77–79 (nine specimens), as opposed to 79–83 (48 specimens) for offshore animals taken from adjacent waters. Offshore animals from more than 800 km offshore tend again to have lower vertebral counts (77–82 in 13 specimens), supporting the concept of an east–west cline within the offshore race.

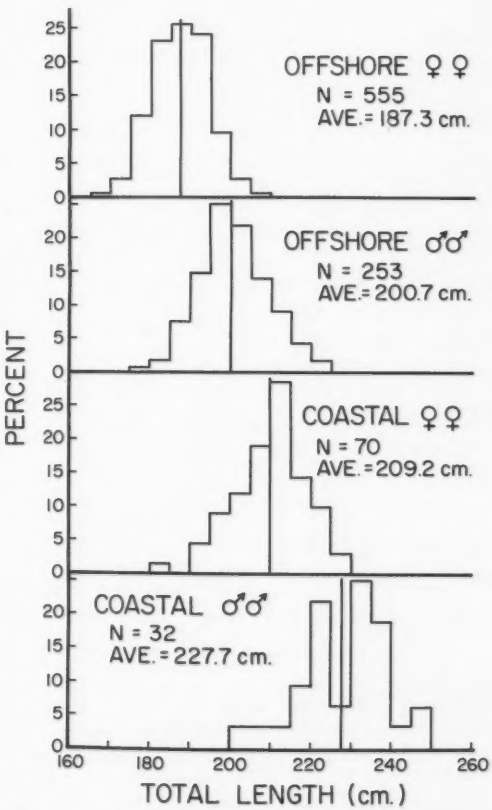

FIG. 2. Histograms of body lengths of spotted dolphins, *S. attenuata*, of two races, collected aboard tuna seiners in 1973. Specimens identified to race on the basis of locality of capture and range of lengths in sample.

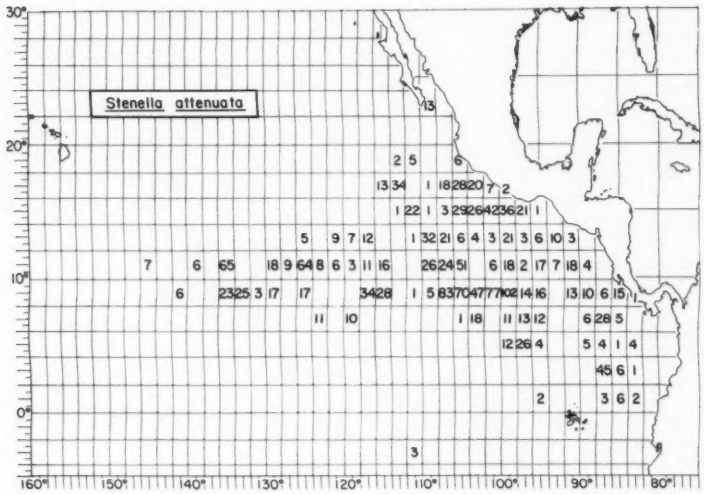

FIG. 3. Numbers of spotted dolphins, *S. attenuata*, tagged, 1969–74, by 2-degree square.

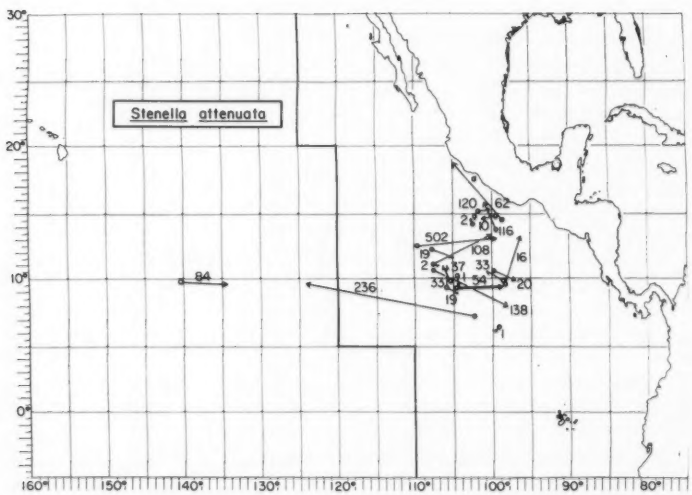

FIG. 4. Net movements of recovered tagged spotted dolphins, *S. attenuata*, with days at liberty.

Recent length data from the fishery also support the concept of two races in the eastern Pacific. Several samples of animals taken in 1973 from within 30 km of the coast of Costa Rica were clearly from a different population than samples taken from more offshore waters throughout the range (Fig. 2). The coastal adult females (those with ovarian scars) were on the average about 22 cm longer than the offshore females. The coastal adult males (those with testes weighing more than 200 g, the smallest size at which sperm has been found in the epididymis) were about 27 cm longer than the offshore males. Calculating from a length–weight relationship (unpublished data), this amounts to an average weight difference in adult males of about 35 kg (115 vs. 80 kg).

We have tagged 11 coastal and 1716 offshore

spotted dolphins (Fig. 3), and recovered 24 tagged offshore animals from known locations (Fig. 4). Time at liberty ranged from 1.7 h to 502 days, and the distance from release point to recapture point ranged from 13 to 2415 km. These results show a great deal of east–west and north–south movement, evidence for extensive mixing within the eastern half of the supposed range of the offshore race. The degree of continuity between the eastern and far-western portions of the range is still unknown because of insufficient tag returns.

The three forms clearly deserve subspecific status (Perrin 1972a). Assignment of trinomials to the offshore and Hawaiian forms will have to wait until the taxonomy of the genus at the species level has been unraveled. Many of the holotypes in *Stenella* are from unknown localities. Relationships among spotted dolphins in the Atlantic and Pacific need to be examined. The name *graffmani*, however, clearly applies to the coastal form, and I therefore provisionally call the coastal form *S. attenuata graffmani*.

Stenella longirostris — There are at least three races of spinner dolphin in the eastern Pacific (Fig. 5), differing modally in several characters (Table 3). One that occurs very near the coast of Central America, referred to below as the "Costa Rican" form, is relatively long, slender, and gray. A second race, called "eastern spinner," occurs along the coast of Mexico and seaward about 800 km and is relatively short, slender, and gray. A third, called "whitebelly spinner", occurs in far offshore waters west to about 145° W long. and is relatively short, robust, and white below. A fourth form occurs in Hawaiian waters and possibly to the south and west and is relatively long, robust, and white below. The ranges of the eastern and whitebelly forms overlap (Fig. 5). In the area of overlap, the two forms are occasionally captured together. A few apparent intergrades have also been collected.

The eastern and whitebelly forms are both involved in the tuna fishery (Table 1). Existence of eastern and whitebelly races was discovered through field observations of color patterns. The Costa Rican–eastern and whitebelly–Hawaiian dichotomies were discovered while examining skeletal specimens.

As with *S. attenuata*, most of the geographical variation in the skull is in features functional in feeding (Perrin 1972a). The Costa Rican spinner has a proportionately longer, more lightly built rostrum and mandible than does the eastern

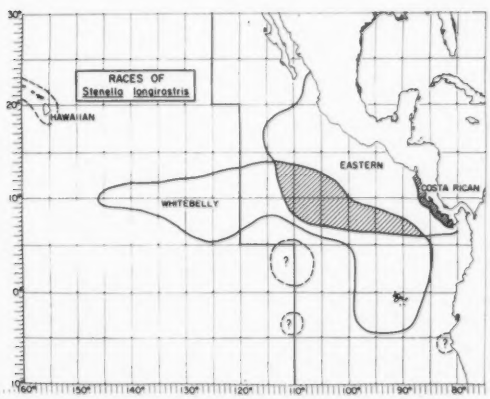

FIG. 5. Known ranges of races of *S. longirostris* in the eastern Pacific. Same data sources as Fig. 1. Boundaries are approximate only, and fluctuate seasonally and from year to year.

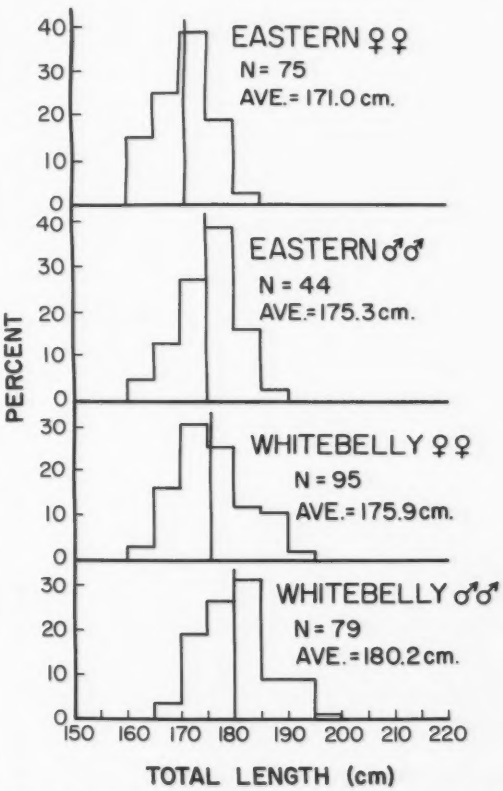

FIG. 6. Histograms of body lengths of spinner dolphins *S. longirostris*, of two races, collected aboard tuna seiners, 1968–73. Specimens identified to race on basis of locality of capture and color pattern.

TABLE 3. Races of *S. longirostris* in eastern Pacific and Hawaiian waters. Length data previously unpublished; other data from Perrin 1972a. Sample sizes in parentheses.

Race	Adult length (*cm*)		Shape of adult males		Color pattern (terminology of Perrin 1972b)	Skull	
	Males	Females	Dorsal fin	Ventral hump		Condylobasal length (*mm*)	Zygomatic width (*mm*)
Costa Rican	181–216 (2)	193–203 (3)	Canted to triangular	—	Poorly known, but like that of eastern.	416–437 (4)	149–152 (4)
Eastern	161–186 (44)	160–181 (75)	Canted to triangular	Medium to extreme	Dark dorsal field obscures cape and extends ventrad, leaving light areas in genital and axillary regions. Monotone effect.	351–407 (26)	139–153 (29)
Whitebelly	170–196 (79)	161–194 (95)	Triangular to falcate	Medium to slight	Dorsal field extends ventrad only to level of eye laterally and has irregular margin. Cape faintly visible through dorsal field. Bipartite effect.	365–419 (13)	145–158 (14)
Hawaiian	185 (1)	183–201 (2)	Falcate	Slight	Light dorsal field to level of eye, with smooth margin. Cape very obvious. Tripartite effect.	431–464 (10)	159–171 (10)

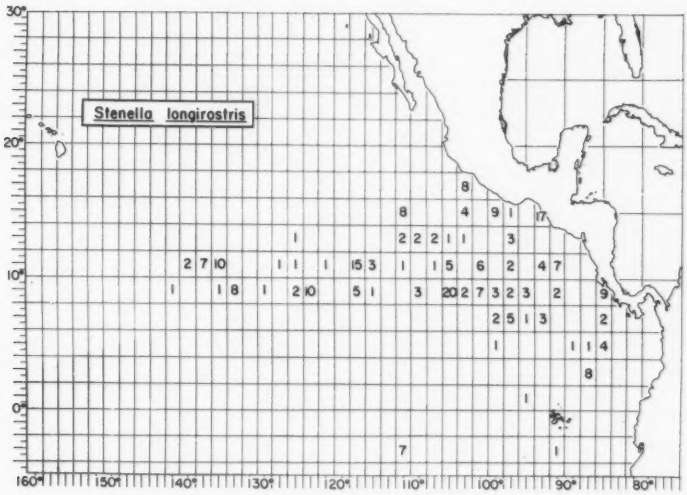

FIG. 7. Numbers of spinner dolphins, *S. longirostris*, tagged, 1969–74, by 2-degree square.

spinner, the reverse of the trend in *S. attenuata*. The skulls of the eastern and whitebelly spinners do not differ in proportion, but the whitebelly skull is on the average slightly larger. The skull of the Hawaiian spinner is longer and broader than those of the other three forms. The four series of specimens can easily be separated statistically (Perrin 1972a).

We know little about the external appearance of the Costa Rican spinner, other than it is very long and slim (a 216-cm male weighed only 57 kg) and has a color pattern very much like that of the eastern spinner. The obviously disparate color patterns of the eastern, whitebelly, and Hawaiian forms can be compared in terms of differential development of a dorsal dark field (Perrin 1972b). The dorsal field is darkest and most extensive in the eastern form and lightest and least extensive in the Hawaiian form. In the Hawaiian form, an underlying dark cape shows strongly through the light dorsal field. The result is to make the coloration of the eastern, whitebelly and Hawaiian spinners effectively uniform, bipartite, and tripartite, respectively. In some apparent intergrades from the area of overlap of the eastern and whitebelly ranges, the dark cape shows faintly through the dorsal field, but the ventral margin of the field is lower and more irregular than in the typical whitebelly spinner.

The dorsal fin of the adult male differs among the three races. In the eastern spinner the tip is forward of midlength of the fin base, giving the fin a reversed appearance. The forward cant is much more developed in some males than in others (Perrin 1972a). In the whitebelly form, the adult male fin is never "reversed" but usually triangular. In the Hawaiian form, it is always at least slightly falcate. Development of a ventral, postanal keel, of unknown function, is correlated with degree of forward cant of the dorsal fin. It is largest in eastern males and nearly absent in Hawaiian males.

The whitebelly form is on the average about 5 cm longer than the eastern form (Fig. 6) and is more robust, having a greater average girth at the axilla (Perrin 1972a). Few measurements are available for the Hawaiian spinner, but it ap-

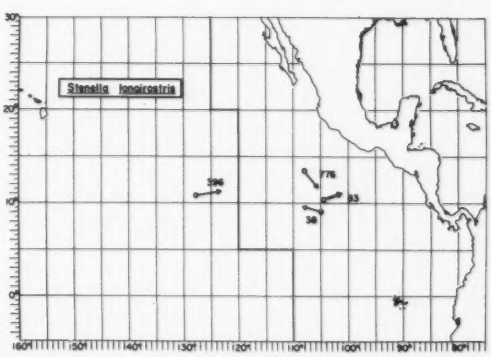

FIG. 8. Net movements of recovered tagged spinner dolphins, *S. longirostris*, with days at liberty.

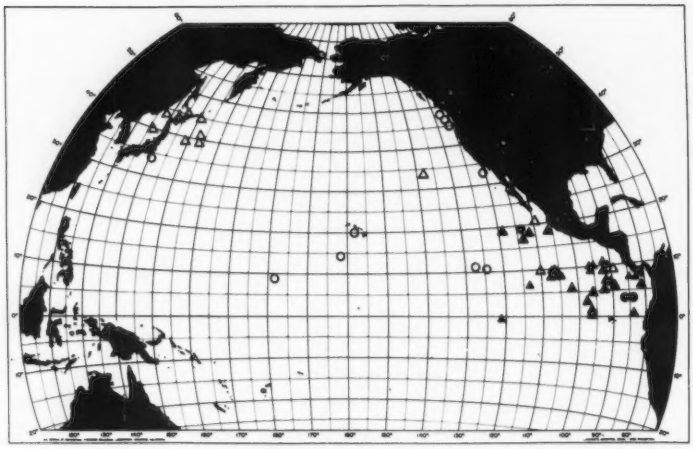

FIG. 9. *Stenella coeruleoalba* in the Pacific. Circles are specimen localities; triangles are sighting localities. Shaded symbols are new records. Open symbols are previously published records (Hubbs et al. 1973).

parently is, on the average, longer than the whitebelly spinner.

We have tagged 242 spinner dolphins (Fig. 7) and recovered five (Fig. 8). Time at liberty ranged from 38 to 776 days, and net distance traveled from 333 to 733 km. Two animals tagged together were recaptured together 83 days later. The limited results show less net movement than for *S. attenuata* and agree with the hypothesis of offshore (eastern) and far offshore (whitebelly) populations.

The four races of spinners deserve subspecific status, but, as is the case for the spotted dolphins, assignment of trinomials must wait until the question of how many species of spinner dolphin exist in the world's oceans has been settled. For the time being, they are best considered as unnamed subspecies of *S. longirostris* Gray.[2]

Stenella coeruleoalba — The striped dolphin was not known from the eastern tropical Pacific until 1970 (Hubbs et al. 1973). In addition to the published locality records (Hubbs et al. 1973) we now have 36 more records, including three for which specimens were collected (Fig. 9). The known range has been extended south to below the equator and east to the Panama Bight. There may be a break in the distribution between about 10° and 17° N lat. This would make the distribution similar to that of *Delphinus* in the eastern tropical Pacific (W. E. Evans personal communication) and may indicate that there is more than one stock. Enough specimens have now been collected from the tropical Pacific (26) so that morphological comparisons can begin to be made between this population or populations and those in the western Pacific and Japan.

Discussion

Geographical races exist for each species of small delphinid that has been closely looked at in the eastern tropical Pacific. It seems reasonable to assume that the eastern Pacific (and world) populations of the other, less well-known delphinids, e.g. *S. coeruleoalba*, *Tursiops*, and *Globicephala*, are similarly subdivided. This points out the need for emphasis on research and management at the stock level.

[2]*Note*: There is room for speculation about the identity of Gray's holotype (Perrin 1972a). The spinner skull that Schlegel in 1846 figured and redescribed as the holotype may not have been the specimen examined by Gray. Gray described his specimen as having a strongly carinated palate, a feature present in *Delphinus* but not in *Stenella*. If Schlegel was indeed mistaken about the origin of the specimen he examined, *longirostris* may be preoccupied by *Delphinus* and unavailable for *Stenella*. However, in the interest of stability of nomenclature and in the light of other known inconsistencies in Gray's work, it seems best to ignore this uncertainty now and retain the long-used *longirostris* for the spinners.

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Ecological Aspects of Smaller Cetaceans, with Emphasis on the Striped Dolphin (*Stenella coeruleoalba*)[1]

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NISHIWAKI, M. 1975. Ecological aspects of smaller cetaceans, with emphasis on the striped dolphin (*Stenella coeruleoalba*). J. Fish. Res. Board Can. 32: 1069–1072.

The striped dolphin (*Stenella coeruleoalba*) is captured by drive fisheries as it migrates along the coast of Japan. The largest school of striped dolphins captured contained 2838 individuals. Annual catches have reached approximately 20,000 striped dolphins, and it is estimated that the population fished must number 400,000–600,000 animals. Recent variations in catch levels have resulted from economic and environmental fluctuations, not from a decrease in population size.

NISHIWAKI, M. 1975. Ecological aspects of smaller cetaceans, with emphasis on the striped dolphin (*Stenella coeruleoalba*) J. Fish. Res. Board Can. 32: 1069–1072.

Le dauphin rayé (*Stenella coeruleoalba*) est capturé par rabattage au moment où il émigre le long de la côte du Japon. Le plus grand banc de dauphins capturés contenait 2838 individus. Les prises annuelles atteignent approximativement 20,000 dauphins et on estimà 400,000–600,000 animaux la population exploitée. Les récentes variations des niveaux de capture sont le résultat de fluctuations économiques et environnementales et non d'un déclin de la population.

Accepted March 14, 1975

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SCHOOLS of striped (*Stenella coeruleoalba*) or blue white dolphins are caught by drive fisheries in the district of Japan, mostly in the Izu Peninsula. In the final stage of fishing, fishermen sometimes enclose the dolphins with a net, but this is not a net fishery. In Taiji Town, fishermen catch striped dolphins with hand harpoons.

In Japan, dolphin fishing is carried out exclusively in areas where local people, or people in nearby districts, like to eat dolphin meat. There is a cultural stigma attached to those who eat dolphin, for it is not considered a luxurious food. Therefore, dolphin consumption is restricted to people in rural communities, primarily those in coastal and mountainous districts where the climate is very cold.

One scientist says that the striped dolphin is the western-most species of the North Pacific, and that it belongs to the *Stenella* population, even though it may sometimes migrate into other areas. Other scientists, however, divide the *Stenella* population into several species each with separate distributions. I am not going to discuss the *Stenella* species here, but am simply presenting the different opinions.

A general migration route is apparent for species of *Stenella* along the coast of Japan (Fig. 1).

Schools of striped dolphins, or ocean dolphins, belonging to the genus *Stenella*, approach the Pacific coast of the Japanese Islands from September to October. They seem to come from the east and head for Point Inubō. There have been few sightings or catch records in the waters north of Point Inubō. They then swim down the Bosoh Peninsula, along the east coast of Ōshima Island, and enter Sagami Bay. At this point, some of the dolphins are captured by the fishermen from Itō by drive fisheries. From Sagami Bay, the dolphins continue south, passing the tips of the Izu and Kii peninsulas, and disperse in the southern seas. A few catches have been reported from Kagoshima Bay in Kyūshū Island. The next April, after parturition and the early stages of nursing in the southern seas, the schools, including the suckling calves and mothers, reappear in the south and move toward the Izu Peninsula. The northbound schools stay far from shore, passing the tip of the Izu Peninsula and continuing on towards Point Inubō. They then head to the east and disappear in the Pacific Ocean. The dolphins are fished by coastal fisheries while passing the Izu Peninsula.

Up until the early 1960s, fishermen of the "Arari" village have caught schools of dolphins, primarily striped dolphins, by drive fishing. The most prosperous period of these fisheries was around 1952. After that, many of the younger

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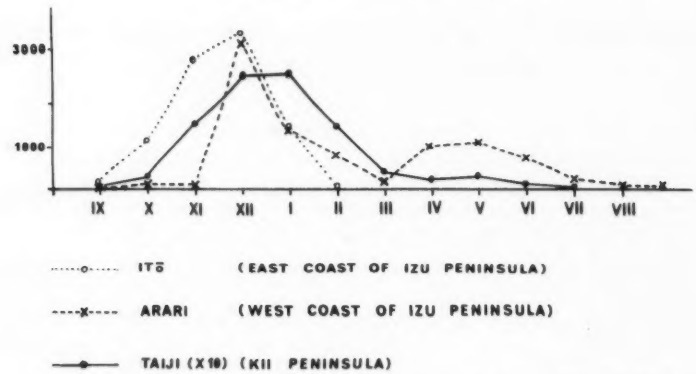
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ITŌ (EAST COAST OF IZU PENINSULA)
ARARI (WEST COAST OF IZU PENINSULA)
TAIJI (X10) (KII PENINSULA)

FIG. 1. Migration route of *Stenella* spp. along the south coast of Japan.

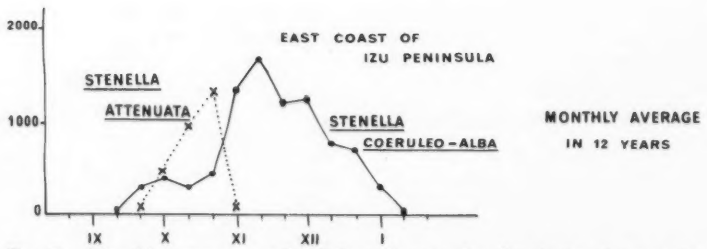

FIG. 2. Monthly average catch of *Stenella coeruleoalba* during the past 15 yr on the coasts of Izu and Kii peninsulas (data collected by Miyazaki).

fishermen started going to the pelagic fishery grounds in search of larger profits. Only middle-aged fishermen continued drive fishing, and their catches dropped. As these fishermen grew old, the drive fisheries disappeared.

Figure 2 shows the average catch per month of past years.

Since Itō Fishermen's Union do only cooperative group hunting in drive fisheries, every time a dolphin school is sighted off shore, they decide whether or not to pursue the school. If they do go out, they all stop fishing. The fishing seasons are from October to January, or sometimes from September to February (Fig. 2), exactly when the striped dolphins are approaching the Izu Peninsula.

There is no group like the Itō Fishermen's Union in the dolphin fisheries in Taiji Town. Owners of small catcher boats fish individually with hand harpoons, and the catch is less than 1/10 of that of the Itō Fishermen's Union. Thus, in Fig. 2 the Taiji catch is drawn on a scale 10 times larger than that from Itō. The fishing season of Taiji starts 1 mo later than that of Itō. It takes 1 mo for the schools of striped dolphins to reach the Kii Peninsula from Sagami Bay.

Taiji fishermen catch both south and northbound schools. The catch of the northbound schools, which arrive in June, is small. This may be partly because the price of dolphin meat is higher in winter than it is in June. Another reason may be that northbound schools are dispersed as they approach the coast. Schools that have gone to the southern seas come together and reform schools offshore between the Kii and Izu peninsulas. It is far easier for Arari fishermen to catch

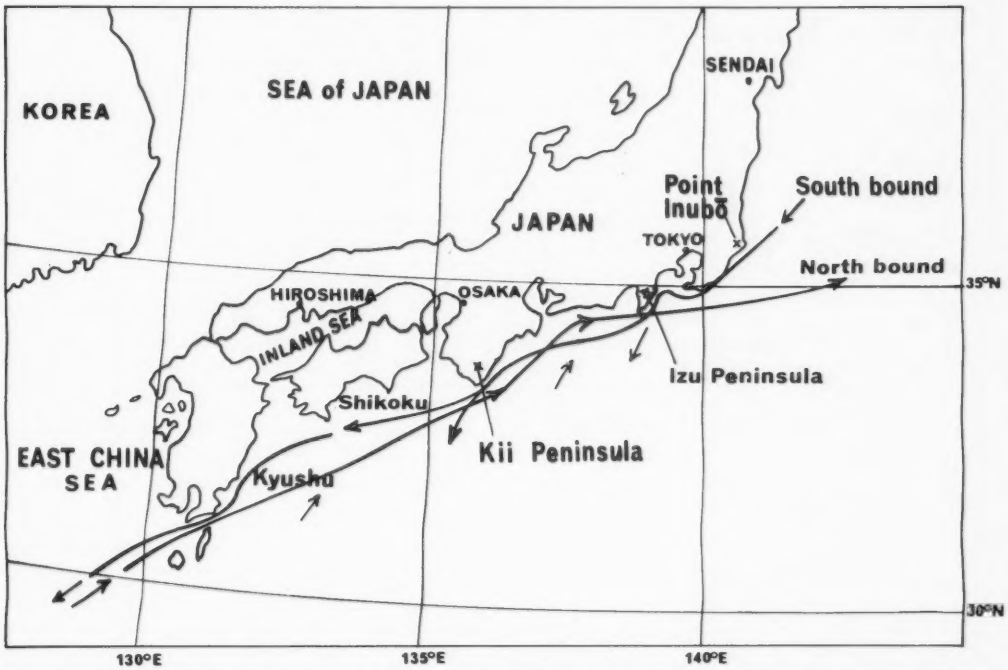

FIG. 3. Ten days average catch of two species of *Stenella* on the east coast of the Izu Peninsula (data collected by Miyazaki).

northbound dolphins, because the dolphins have formed schools with great numbers of animals by the time they reach Izu. The fishermen meet them at the mouth of Suruga Bay and drive them into the narrow inlets.

After passing this dangerous coast, the schools may continue migrating in the North Pacific, far off the Japanese coast, from June until October.

The number of individuals in a school of the striped dolphins varies. There are fewer than 100 animals in the smaller schools, and 2000–3000 animals in the larger ones. Southbound schools are larger and are close together. Northbound schools are smaller, and pass one another sporadically. Drive fisheries often catch a whole school, but sometimes in a crisis a school will split into two or three groups, and fishermen can then catch only a part of the school.

Although studies of the schools have been incomplete, the following is known: pregnancy rate is high in schools of mature individuals; the gestation period is thought to be 11–12 mo. Parturition may occur in spring or in fall, depending on the individual. The calf is nursed by the mother, protected for half a year, and cared for about 2 yr; in schools of mature animals, calves younger than 2 yr are intermingled within the school.

It is not clear how the 2-yr-old calves part from their mothers, but they group together and form large schools of immature individuals. Immature animals mature in 5–6 yr, although one scientist says that maturity is reached only after 8 yr. No adult males have been found in immature schools, but adult females have been found at a rate of 0.3% and probably left their original schools to follow their young. Immature schools do not seem to transform into mature schools. If such were the case, each school might be formed only of animals of equal or similar age, but the mature schools contain animals of all ages except those between 3 and 5 yr old. It seems that young dolphins individually join adult schools when they reach 6 or 7 yr old. Whether or not they join their parents' school is unknown.

At certain places on the east coast of Japan, one may observe schools of different species of dolphins coming near shore, one by one, as indicated by the catch record (Fig. 3). *Stenella attenuata* comes about 3 wk earlier than *S. coeruleoalba*, although no catch has been recorded;

TABLE 1. The frequency of school size in *Stenella coeruleoalba* on the Izu Peninsula.

School size	East coast (%)	West coast (%)
0–49	9	39
	(9.9)	(18.8)
50–99	6	52
	(6.6)	(25.0)
100–199	21	42
	(23.1)	(20.2)
200–299	19	22
	(20.9)	(10.6)
300–499	18	27
	(19.9)	(13.0)
500–999	12	17
	(13.2)	(8.2)
1000–1999	4	8
	(4.4)	(3.8)
2000–2999	2	1
	(2.2)	(0.5)

No. individuals

Range	Avg
25–2838	East Coast 379
16–2005	West Coast 235

Lagenorhynchus obliquidens has been sighted 1 mo later than *S. coeruleoalba*.

A survey of the school sizes of various species caught on the Izu Peninsula's east coast in the past 6 yr shows that the largest school of striped dolphins caught contained 2838 individuals, and that the average school contained 366 individuals. Schools of *S. attenuata* contained 98–1351 individuals, the average of which was 360. There were 15–293 individuals in schools of *Tursiops truncatus*, giving an average size of 92. Schools of *Steno bredanensis* contained 33–53 individuals, its average being 40. *Grampus griseus* schools had 7–132 individuals, with an average of 44. The only school of *Pseudorca crassidens* caught contained 60 individuals. The number and frequency of dolphins migrating into Sagami Bay is outlined in Table 1. One must remember, however, that there are other dolphins that are very alert and difficult to catch, such as *Lagenorhynchus obliquidens*.

The striped dolphins entering Sagami Bay are pursuing squid that are abundant along the east coast of the Izu Peninsula. Squid are found in dolphin stomachs, and the jaws of dolphins are scarred by the suckers of the squids' tentacles. Local fishermen, who fish squid to earn their living, do not think of dolphins as harmful, and catch both squid and dolphins. If the dolphin catch were to be banned, they might think that dolphins were harmful to their fishing harvest.

Drive fisheries often kill whole schools of dolphins. Requests to fishermen to release young animals have almost always been ignored. The fishermen argue that if they release an infant, it would soon die, and also, that the meat of infants is more tender, and therefore brings a higher price than does adult meat. Even when we release tagged animals, fishermen tend to be far from cooperative.

When I first witnessed those abundant catches at the fishing villages of Izu, I worried that the catches of 5000–10,000 dolphins would decrease the catch number, or result in decreased body length before long. Although I have observed variance in body length according to age, I have seen no decline in average body length of caught individuals. Variation in catch levels has resulted from low market prices of the meat, and fluctuations in the weather and water temperature (Miyazaki et al. 1974), rather than from a progressive decrease in catch number.

In view of my observations, I conclude that the catch of drive fisheries has not had an evident effect upon the large population of offshore dolphins If one estimates that the catch of striped dolphins is 20,000, a rough estimation of the dolphin population off the Japanese Islands may be 20–30 times this number. This would mean that there are 400,000–600,000 dolphins off Japan. I do not think that this estimate of the *Stenella* population is too large.

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Progress Report on the Biology of the Franciscana Dolphin, *Pontoporia blainvillei*, in Uruguayan Waters[1]

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BROWNELL, R. L., JR. 1975. Progress report on the biology of the Franciscana dolphin, *Pontoporia blainvillei*, in Uruguayan waters. J. Fish. Res. Board Can. 32: 1073–1078.

Over 400 Franciscana dolphins, *Pontoporia blainvillei*, were examined throughout the 12-mo fishing season that they are captured in gillnets set for sharks off Uruguay. Female sexual maturity was at 137–146 cm. Near-term fetuses 63–70 cm long were found between September and December. Main prey species in the austral summer were *Cynoscion striatus, Porichthys porosissimus* and *Trichiurus lepturus,* and in the austral winter, *C. striatus, Trachurus lathami,* and *Engraulis anchoita*. Common internal parasites included nematodes, *Contracaecum* sp. and at least one other genus, from the main stomach, and an acanthocephalan, *Polymorphus cetaceum*, found only in the stomachs. Past catches include a minimum of 536 between 1969 and 1973 taken in all months.

BROWNELL, R. L. JR. 1975. Progress report on the biology of the Franciscana dolphin, *Pontoporia blainvillei*, in Uruguayan waters. J. Fish. Res. Board Can. 32: 1073–1078.

Plus de 400 *Pontoporia blainvillei* ont été examinés au cours des 12 mois de la saison de pêche où ils sont capturés dans des filets maillants tendus pour la pêche des requins au large de l'Uruguay. La maturité sexuelle des femelles se situe à 137–146 cm. Des foetus de 63–70 cm presque à terme furent trouvés entre septembre et décembre. Les principales espèces proies durant l'été austral sont *Cynoscion striatus, Porichthys porosissimus,* et *Trichiurus lepturus*, alors que durant l'hiver austral, *C. striatus, Trachurus lathami,* et *Engraulis anchoita*. Parmi les parasites internes communs, on note des nématodes, *Contracaecum* sp. et au moins un autre genre dans l'avant-estomac et un acanthocéphale, *Polymorphus cetaceum*, dans l'estomac. Les prises passées comprirent un minimum de 536 individus entre 1969 et 1973, capturés à tous les mois de l'année.

Accepted March 14, 1975 Accepté le 14 mars 1975

THE Franciscana dolphin, *Pontoporia blainvillei*, is a small dolphin restricted to coastal central Atlantic waters of South America. The actual range of this species is from Valdes Peninsula, in northern Chubut, Argentina, north to the Tropic of Capricorn around Ubatuba, Brazil (Praderi *In* Ximenez et al. 1972). I know of no records from the Uruguay and Parana rivers which empty into the La Plata estuary.

Pontoporia is currently placed in the river dolphin family Platanistidae with three other allopatric genera. All four genera of dolphins are long-snouted and similar in appearance; the Franciscana is the smallest. The other members of the family Platanistidae are: the white flag dolphin, *Lipotes vexillifer*, known only from the Tung Ting Lake, China; the Susu or Blind River dolphin, *Platanista gangetica*, widely distributed in the Ganges, Brahmaputra, and Indus river (*P. indi*) systems of India, Bangladesh, and Pakistan; and the Boutu or Amazon river dolphin, *Inia geoffrensis*, found in the Amazon and Orinoco river basins. *Pontoporia* is the only member of the family that inhabits salt water.

At Punta del Diablo, Uruguay, Franciscanas and two species of sea lions are caught in gillnets by local fishermen in shark fishing operations. The gillnets (trasmallos) are approximately 197 ft in length and 10 ft in depth. Two nets are joined together to form what is called a vaga. Each boat (chalana or lancha) has between 8 and 14 vagas. The mesh size is either 4.4 or 6 inches, depending upon the size of the sharks. Additional details on the fishing methods used at Punta del Diablo are given by Van Erp (1969), Brownell and Ness (1970), and Pilleri (1971a). Similar fishing operations occur at three other localities along the Uruguayan coast.

Some of the more important older references

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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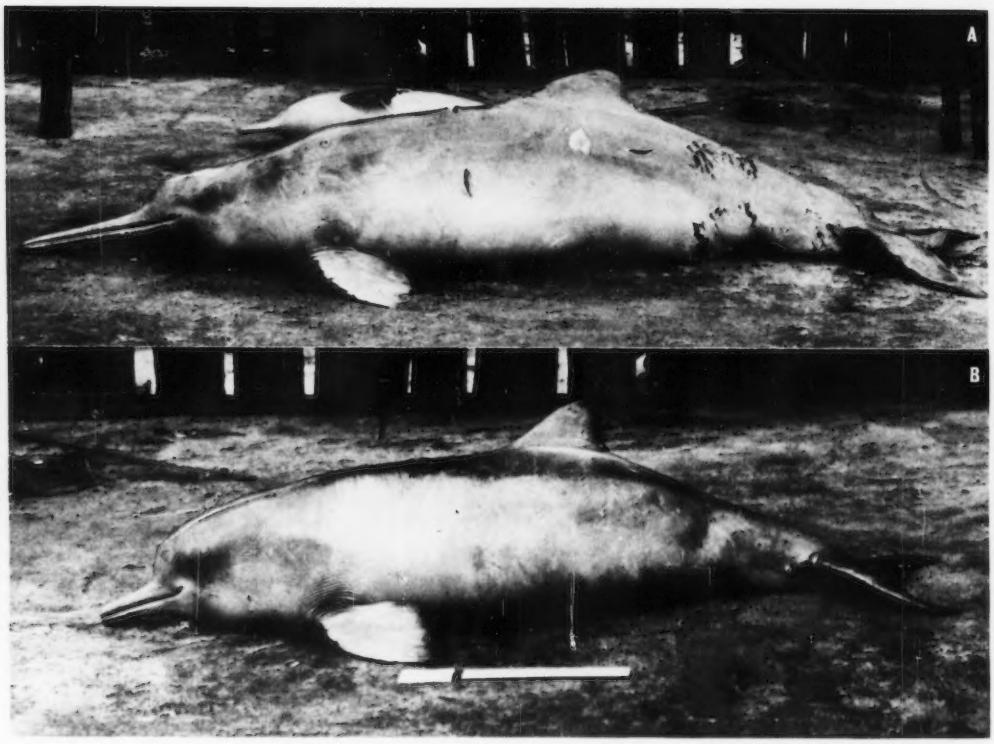

FIG. 1. Franciscana dolphins, *Pontoporia blainvillei*, taken incidentally in gillnet fishery for sharks at Punta del Diablo, Uruguay. A, Lateral view of lactating female, specimen RLB 837, 160 cm long, weight 45.5 kg, taken offshore of Punta del Diablo on December 28, 1972 (photo 26: 24). B, Lateral view of juvenile, taken in same net close to above female and possibly its calf, specimen RLB 838, 84.5 cm long, weight 10.9 kg (photo 26: 29).

that deal with *Pontoporia* are Burmeister (1869), Lahille (1899), and Cabrera and Yepes (1940), but these reports give little information on the biology and ecology of this species. Recent authors deal with biology and ecology, but their findings are based on few dolphins: Carvalho (1961); Brownell and Ness (1970); Fitch and Brownell (1971); Harrison and Brownell (1971); Pilleri (1971a, b); Pilleri and Gihr (1971).

A research project on the life history and ecology of *Pontoporia* was initiated in January 1969 and field work is continuing in Uruguay. This paper is a preliminary summary of the information to date (December 1973) on those aspects of the Franciscana's biology that have bearing on the management of the species (Fig. 1).

Materials and Methods

Two reconnaissance trips in February and August 1969 were conducted to determine the feasibility of a study on *Pontoporia* in Punta del Diablo. These proved successful and a research program was started in December 1970. The baseline study terminated December 1973, during which period biological data and specimens were collected from more than 400 dolphins.

Nomenclature

The generic name *Stenodelphis* d'Orbigny, 1847 was used throughout most of this century, but Hershkovitz (1961) stated that *Pontoporia* Gray 1846 is the earliest valid generic name for the Franciscana dolphin. Hershkovitz (1961) stated that the problem is that this "widely circulated name is not a homonym of *Pontoporeia* Kroyer, 1842, a crustacean, nor has it been proven that the name is antedated by *Pontoporia* Agassiz, 1846 (Nomencl. Zool., p. 305), an invalid emendation of *Pontoporeia* Kroyer." *Stenodelphis* is a junior objective synonym for *Pontoporia*.

Delphinus blainvillei was described by Gervais and d'Orbigny (1844). The type specimen, a skull was collected near Montevideo, Uruguay. It was deposited in the Museum National d'Histoire Naturelle, Paris.

The only other nominal species described in this genus is *P. tenuirostris* by Malm in 1871. The holotype, a mounted skin and skull, was collected in Montevideo, Uruguay, and is deposited in the Goteborg Naturhistoriska Museum, Sweden.

Age and Growth

Dr T. Kasuya and I are sectioning teeth from all specimens collected during this study. Preliminary findings indicate that mature females have a minimum of seven dentinal growth layers.

The maximum size of male and female *Pontoporia* is 158 and 174 cm, respectively (Lahille 1899). The largest male and female Franciscanas that I have examined were 152 and 173 cm, respectively.

Reproductive Cycles

Harrison and Brownell (1971) and Harrison et al. (1972) summarized available data on the reproductive cycles of male and female *Pontoporia blainvillei*. They reported that females became sexually mature between total lengths of 134 and 137 cm; males at lengths greater than 140 cm.

During the study a total of 220 females and 213 males were examined to determine their reproductive state. The length frequencies of females and males examined are given in Tables 1 and 2 (all total length measurements were taken in a straight line from the tip of the rostrum to the notch in the flukes).

The smallest mature and largest immature females were 137 and 146 cm, respectively. The smallest male and female were 84 and 85 cm, respectively. The largest fetuses examined were a 70-cm female and a 68-cm male. Five near term fetuses were collected between September and December, with total lengths between 63 and 70 cm. Two fetuses had an average body length 44.5% of the mother's length.

The ovaries of adult females have not yet been sectioned. Only two to four surface corpora albicantia have been observed. The corpus luteum persists until parturition; an accessory corpus luteum is sometimes present, and it probably occurs simultaneously with conception, as is suggested for the beluga (*Delphinapterus leucas*; Brodie 1972).

Only 24 males (0.1%) were over 140 cm in total length. Tissue slides are presently being prepared from testicular samples.

Food Habits

Fitch and Brownell (1971) summarized available data on the food habits of *P. blainvillei*. Fish, squid, octopus, and shrimp are reported to be eaten. During the current study, food habits of the Franciscanas, sea lions, and sharks were studied to obtain information on feeding strategies and seasonal variation in the feeding habits of these top trophic feeders. The materials are currently being analyzed, but the following preliminary comments can be made.

TABLE 1. Body length, frequency, and maturity of female Franciscana dolphins, *Pontoporia blainvillei*, examined at Punta del Diablo, Uruguay. (These data include animals from Brownell and Ness [1970], table 1.)

Size range (*cm*)	Number	No. and % sexually mature
81–85	1	
86–90	0	
91–95	1	
96–100	6	
101–105	12	
106–110	8	
111–115	14	
116–120	19	
121–125	17	
126–130	19	
131–135	11	
136–140	16 + (11)	7–48%
141–145	14 + (6)	12–86%
146–150	9 + (3)	8–89%
151–155	15 + (5)	15–100%
156–160	11 + (6)	11–100%
161–165	5 + (4)	5–100%
166–170	3 + (2)	3–100%
171–175	1 + (1)	1–100%
81–175	220	

TABLE 2. Body length, frequency of male Franciscana dolphins, examined at Punta del Diablo, Uruguay. (This includes data from Brownell and Ness [1970], table 1.)

Size range (*cm*)	Number	Percent of total
81–85	3	0.014
86–90	1	0.005
91–95	4	0.019
96–100	9	0.042
101–105	10	0.047
106–110	12	0.056
111–115	22	0.103
116–120	24	0.113
121–125	30	0.140
126–130	28	0.131
131–135	21	0.098
136–140	25	0.117
141–145	12	0.056
146–150	9	0.042
151–155	3	0.014
81–155	213	0.997

The predominant food organisms taken by *P. blainvillei* during the austral summer were *Cynoscion striatus*, *Porichthys porosissimus*, and *Trichiurus lepturus*. These prey species were probably taken at, or near, the bottom by the Franciscanas.

Other fish found in the stomachs of these dolphins are: cf. *Anchoa* sp., *Ariosoma* sp., *Conger multidens*, cusk eel, *Cupiceps* sp., *Engraulis anchoita*, goby, *Macrodon ancylodon*, *Polyclemus brasiliensis*, *Micropogon furnieri*, *Peprilus* sp., *Stromateus brasiliensis*, *Symphurus* sp., *Trachurus lathami*, *Umbrina canosai*, and *Urophycis* cf. *U. brasiliensis*.

During the austral winter *P. blainvillei* fed mainly upon *Cynoscion striatus*, *Trachurus lathami*, and *Engraulis anchoita* which were very common in relatively shallow coastal Uruguayan waters. *Cynoscion striatus* is also an important food item for sea lions and sharks in these waters, but Franciscanas fed on smaller-sized individuals.

The squid, identified from their beaks, were *Lolliguncula brevis*, and shrimp of the following species: *Artemesia longinaris*, *Hymenopenaeus mulleri* and *Penaeus* (*Melicertus*) *paulensis* have all been recorded from the stomach contents of *P. blainvillei*.

Endoparasites

Two types of parasites have been reported from *P. blainvillei* (Dailey and Brownell (1972) and Schmidt and Dailey (1971)). One is an acanthocephalan, *Polymorphus* (*Polymorphus*) *cetaceum* (Johnston and Best 1942); the other is a nematode, *Contracaecum* sp. Both of these parasites have been found only in the stomach. I observed four species of endoparasites associated with the digestive system, including one trematode, one cestode, one nematode, and one acanthocephalan. No parasites were found in the lungs, intestine, heart, brain, kidneys, body cavity, blubber, or air sinus system. The number of parasites observed was recorded in the field as light (1–25), medium (25–100), and heavy (100+) infestations.

Trematodes — An as yet unidentified fluke was found in only one Franciscana. This specimen may have come from the liver.

Cestodes — Several unidentified cestode larvae were found attached to the outer surface of the lower intestine of one dolphin. A specific search was not made for cestodes in the 193 Franciscanas examined for nematodes and acanthocephalans, but because of their external attachment and location, it would be difficult to overlook them. I consider them to be uncommon. It is noteworthy to report the absence of larval cestodes (*Phyllobothrium* spp.) in the blubber and *Monorygma* spp. in the lower abdominal cavity of this species. Both of these parasites have been reported from almost all the genera of marine odontocetes (Dailey and Brownell 1972).

Nematodes — Nematodes were found in 97 (51.0%) of 190 Franciscanas examined. *Contracaecum* sp. and at least one other genus were collected. These nematodes were found in the main stomach compartment and were either free or firmly attached to the mucosa. In only two cases were nematodes found in the stomach without acanthocephalans. The infestation rate in animals observed and recorded in the field for nematodes was 94 = light, 3 = medium, and 0 = heavy.

Acanthocephalans–Polymorphus (*Polymorphus*) *cetaceum* (Johnston and Best 1942) occurred in 175 (91.6%) of 191 dolphins examined. The site of attachment of this acanthocephalan was in the stomach, mainly in the passage connecting the first and second compartments. The infestation rate of *P. cetaceum* was recorded in 175 animals and was: 118 (67.4%) light, 47 (26.9%) medium, and 10 (5.7%) heavy.

The site of occurrence of *P. cetaceum* in the stomach of *Pontoporia* is unique among vertebrates higher than fishes. In all other higher vertebrates, acanthocephalans are known only from the intestines. All acanthocephalans were firmly attached to the mucous membrane of the stomach. No lesions were produced except for local irritation at the site of attachment.

Isopods — I found isopods (*Cirolana* sp.) on several occasions in the blowhole and stomach of *P. blainvillei*. Only two previous reports noted the occurrence of isopods associated with cetaceans. Hale (1926) listed *Cirolana woodjonesi* from a porpoise (no scientific name given) and Bowman (1971) reported a new species (*Cirolana narica*) from the blowhole of the Hector's dolphin *Cephalorhynchus hectori*. The association between *Cirolana* and dolphins is not well understood, but these isopods probably enter the dolphin's blowhole after death. These isopods are commonly observed in the gills of dead sharks taken in gillnets in Uruguayan waters.

Ectoparasites

Before these studies, no ectoparasites had been reported from the Franciscana. I found two species of ectoparasites, both of which were crustaceans. One was a barnacle and the other an isopod.

Barnacles — *Xenobalanus* is a genus of pseudo-stalked, sessile cirriped that is commonly found on cetaceans. Two dolphins each had one specimen of this sessile barnacle attached on the flukes, one at the tip and the other in the notch. The same species of pseudo-stalked barnacle *Xenobalanus* cf. *X. globicipitis* Steenstrup has been reported from various other species of cetaceans.

Cyamids — No cyamids were observed on Franciscanas.

Isopods — A parasitic isopod (*Nerocila* sp.) previously known only from sharks and fishes was found attached to the skin in the neck region of one dolphin. The isopod may have transferred from a shark or fish to the *Pontoporia* while the dolphin was in the gillnet.

Diatoms — Diatom films were observed on the dorsal and lateral surfaces of most fresh Franciscanas examined. Samples were collected from a few *Pontoporia* and are currently under study to determine the species involved.

Predators

The sevengill shark (*Notorynchus ocellatus*) is a predator on the dolphins caught in shark gillnets, but it is not known if this shark preys on free ranging dolphins. Remains of sea lions have also been found in the stomachs of sevengill sharks, but marine mammal remains have not been found in the stomachs of any of the larger sharks in these waters.

Killer whales (*Orcinus orca*) are commonly sighted around the various offshore Uruguayan islands which support large sea lion populations (*Arctocephalus australis* and *Otaria flavescens*; Brownell et al. 1973). I assume that *Orcinus orca* is predatory on *Pontoporia*, but I do not know of any definite cases.

Naturally Occurring Diseases

Normal tissue samples and those with possible pathology were collected from all major organ systems. Gross pathologic conditions were observed in the following localities: lungs, aorta, adrenals, uterus, and stomach. An adult male, 147 cm in length, had small punctate atherosclerotic lesions on the thoracic segment of the aorta, but less than 5% of the intimal surface was involved. A number of dolphins had ulcerated sores present in the main compartment of their stomachs, probably the result of parasitic nematode activity. No additional results are yet available on the other samples obtained from these dolphins.

TABLE 3. Catch statistics of the Franciscana dolphin between 1969 and 1973 at Punta del Diablo, Uruguay.

	1969	1970	1971	1972	1973	Total
Jan.			98		51	149
Feb.	10		11			21
Mar.			25			25
Apr.			11			11
May			7			7
June			10		10	20
July			20	4	6	30
Aug.	1		24	20		45
Sept.			5	26	4	35
Oct.			5	20	15	40
Nov.			7		21	28
Dec.		28[a]	8	45	44	125
Total	11	28	231	115	151	536

[a]Includes seven listed by Pilleri (1971a).

Environmental Pollution

A small number of samples were collected for organochlorine analyses. No results are available at this time. Samples will be collected from *P. blainvillei*, fur seals, and southern sea lions for organochlorine and heavy metal analyses.

Past Exploitation

Brownell and Ness (1970) reported that fishermen at Punta del Diablo in 1969 estimated the annual catch of Franciscana at 2000. Pilleri (1971a), based on his contact with the same fishermen in 1970, estimated that about 1500 are caught annually. Past exploitation by these fishermen "must have been" on Franciscanas as the fishing grounds were closer to shore (Pilleri 1971a). Over the years the fishing grounds have moved farther offshore due to the shark populations' moving offshore. Boats fishing 30–40 km offshore do not catch *P. blainvillei* in their gillnets, but fishing with smaller gillnets for teleost fishes in inshore waters has increased during the past few years.

This shark fishery at Punta del Diablo started in 1942 (Van Erp 1969). Some catch statistics for *P. blainvillei* between 1969–73 at Punta del Diablo are presented in Table 3.

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Punta del Diablo, the Toscano and Redin families in Montevideo, and especially all the fishermen of Punta del Diablo who made my work in the village possible. Additional support came from: H. A. Fehlmann (Smithsonian Oceanographic Sorting Center), I. E. Wallen and W. I. Aron (both formerly S. I., Office of Environmental Sciences), and M. Nishiwaki (University of Tokyo) and his staff. Major financial support came from the National Geographic Society, U.S. Navy Office of Naval Research, and the Smithsonian Institution. Additional support was from the National Science Foundation (R/V *Hero* cruise), Museo Nacional de Historia Natural de Montevideo, and the Ocean Research Institute, University of Tokyo. J. E. Fitch and M. D. Dailey provided assistance with the identifications of stomach contents and parasites, respectively. I wish to express my sincere thanks to S. Toscano of Montevideo and all of these individuals and institutions for their aid and cooperation.

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Preliminary Notes on the Occurrence and Exploitation of Smaller Cetacea in Greenland[1]

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KAPEL, F. O. 1975. Preliminary notes on the occurrence and exploitation of smaller Cetacea in Greenland. J. Fish. Res. Board Can. 32: 1079–1082.

Approximately 1000 common or harbour porpoises (*Phocoena phocoena*) are taken annually, not including the by-catch in salmon driftnets. Catches of narwhal (*Monodon monoceros*) and beluga (white whale, *Delphinapterus leucas*) fluctuate in the low to middle hundreds annually. Estimates of the annual catches in the Thule district are 100 beluga and 300 narwhals. Sporadic catches of long-finned pilot whales (*Globicephala melaena*) seldom exceed 100 animals per annum. Catches of minke whale (*Balaenoptera acutorostrata*) have risen since the late 1950s, with approximately 200 or more per annum taken in West Grenland since the mid 1960s. An annotated bibliography of titles on smaller Cetacea in Greenland is given.

KAPEL, F. O. 1975. Preliminary notes on the occurrence and exploitation of smaller Cetacea in Greenland. J. Fish. Res. Board Can. 32: 1079–1082.

Il se capture environ 1000 marsouins (*Phocoena phocoena*) annuellement, sans compter les prises fortuites des filets maillants à saumon. Les prises de narvals (*Monodon monoceros*) et de bélugas (*Delphinapterus leucas*) varient d'un peu plus de 100 à environ 500 par année. Les prises annuelles dans le district de Thule sont estimées à 100 bélugas et 300 narvals. Les prises sporadiques de globicéphales noirs (*Globicephala melaena*) dépassent rarement 100 animaux par année. Les prises de petits rorquals (*Balaenoptera acutorostrata*) ont augmenté depuis la fin des années 1950, environ 200 ou plus étant capturés au Groenland occidental depuis le milieu des années 1960. L'auteur donne une bibliographie annotée de publications sur les petits cétacés du Groenland.

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Species known from Greenland

Ten species of smaller Cetacea are known from Greenland waters: minke whale (*Balaenoptera acutorostrata*), northern bottlenose whale (*Hyperoodon ampullatus*), narwhal (*Monodon monoceros*), beluga or white whale (*Delphinapterus leucas*), long-finned pilot whale (*Globicephala melaena*), killer whale (*Orcinus orca*), white-beaked dolphin (*Lagenorhynchus albirostris*), Atlantic white-sided dolphin (*L. acutus*), striped dolphin (*Stenella coeruleoalba*), and common or harbour porpoise (*Phocoena phocoena*).

LESS COMMON OR UNEXPLOITED SPECIES

The striped dolphin and white-beaked dolphin have been recorded only once or a few times, whereas white-sided dolphins have occurred more frequently, but irregularly and not in great numbers. Bottlenose and killer whales seem to be rather common visitors, at least in some periods, but none of the species mentioned are important objects of hunting.

During the 1920s and 1930s pilot whales occurred in greater numbers than before. They have occasionally been exploited locally (Fig. 1). This period of abundance is evidently related to hydrographic effects, specifically a warmwater period (Dunbar 1947).

MORE COMMON OR EXPLOITED SPECIES

The common porpoise, beluga, narwhal, and the minke whale, are the important species in Greenland (Fig. 2, 3, 4).

Common porpoise — The porpoise is very common in West Greenland waters during spring, summer, and autumn, especially in the ice-free regions between Frederikshåb and Holsteinsborg (61–68°N). It is also known from East Greenland, but is not common and is of no importance to the local population.

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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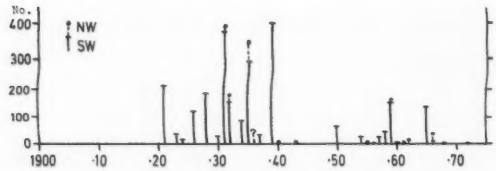

FIG. 1. The Greenlanders' catch of long-finned pilot whales, *Globicephala melaena*, in West Greenland.

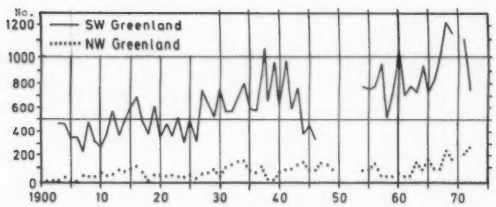

FIG. 2. The Greenlanders' catch of common or harbour porpoises, *Phocoena phocoena*, in Greenland.

Porpoises have always been of some importance to the hunters in southwest Greenland, and the annual catch has ranged between 400 and 800 in the period 1900–50 (Fig. 2). According to hunting statistics, the catch has been slightly higher in the last 20 yr, and the figures for southwest Greenland are probably too low for that period. The total output of the hunting, which for the most part is carried out occasionally from small fishing boats, is estimated to be around 1000 animals per year. In addition to this, several hundred porpoises have been taken in salmon driftnets by fishing vessels operating in Davis Strait during the last few years, but the total size of these by-catches is not certainly known (see paper by Lear and Christensen this volume).

Beluga and narwhal — The beluga is common in the coastal waters of central and northern West Greenland, and more sparse in southwest Greenland (where it was common until the beginning of this century), and East Greenland. The narwhal has a similar but more northerly distribution. Especially narwhals, but also belugas, are very abundant in the Thule district (75–79°N) in the summer, but spend the winter in the Disko Bay area.

In the Thule district the hunting is often carried out in the traditional way, with the use of kayaks and harpoons, plus rifles, but in other parts of the country the whales are more often shot from, or driven into nets by motor boats. Occasionally they are taken in holes in the sea ice ("savssats").

The fluctuations in the catch in West Greenland of both species are shown in Fig. 3. This statistical material is considered reliable, but it does not include figures for the catch in the Thule district, which is estimated to be of the order of 100 belugas and 300 narwhals annually. In the remaining part of northwest Greenland (NW in Fig. 3), narwhals account for 20–25%, and even less in southwest Greenland. Catches in East Greenland are insignificant.

Minke whale — Minke whales are common visitors in Greenland waters during the summer and autumn, but were not exploited by the Greenlanders until recently.

Since the late 1950s, several cutters and small fishing vessels have been equipped with harpoon guns, and an increasing number of minke whales are taken occasionally during fishery operations (Fig. 4).

LITERATURE ON SMALLER CETACEA IN GREENLAND

Several notes on the occurrence and exploitation of whales in Greenland can be found in the newspaper "Atuagagdliutit" (in Greenlandic 1861–

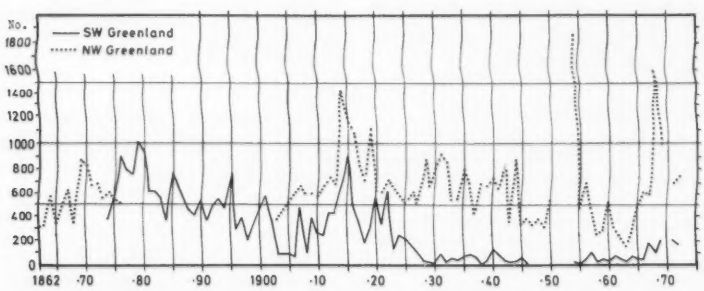

FIG. 3. The Greenlanders' catch of narwhals, *Monodon monoceros*, and belugas or white whales, *Delphinapterus leucas*, in Greenland.

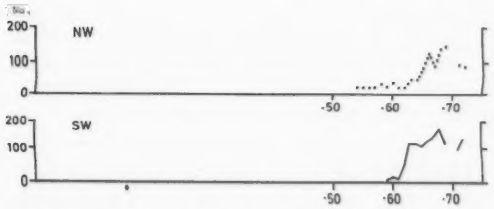

FIG. 4. The Greenlanders' catch of minke whales, *Balaenoptera acutorostrata*, in West Greenland.

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Preliminary Report on the Norwegian Fishery for Small Whales: Expansion of Norwegian Whaling to Arctic and Northwest Atlantic Waters, and Norwegian Investigations of the Biology of Small Whales[1]

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CHRISTENSEN, I. 1975. Preliminary report on the Norwegian fishery for small whales: expansion of Norwegian whaling to arctic and northwest Atlantic waters, and Norwegian investigations of the biology of small whales. J. Fish. Res. Board Can. 32: 1083–1094.

Whaling for minke whales commenced off Norway in the 1920s. The fishery expanded to the Shetland–Faeroe Islands by 1938–39, to Denmark Strait by 1966, and to Labrador in 1969. Bottlenose whale catches have declined, partly due to economic factors. Modern catches of minke whales are 2000–2500 per annum. Evidence from length-group frequencies and sex composition indicate separate minke stocks in east and west North Atlantic. Segregation by age and sex is documented.

CHRISTENSEN, I. 1975. Preliminary report on the Norwegian fishery for small whales: expansion of Norwegian whaling to arctic and northwest Atlantic waters, and Norwegian investigations of the biology of small whales. J. Fish. Res. Board Can. 32: 1083–1094.

L'exploitation des petits rorquals débuta pendant les années 1920 au large de la Norvège. La pêcherie s'était propagée aux îles Shetland–Féroé en 1938–39, au détroit du Danemark en 1966 et au Labrador en 1969. Les prises d'hypéroodons ont décliné, en grande partie à cause de facteurs économiques. Les prises modernes de petits rorquals sont de 2000–2500 par année. Les fréquences de longueurs et la proportion des sexes indiquent des stocks distincts de petits rorquals dans les secteurs est et ouest de l'Atlantique Nord.. Nous démontrons qu'il y a ségrégation selon l'âge et le sexe.

Accepted March 14, 1975 Accepté le 14 mars 1975

SMALL whales have been hunted in Norwegian waters for several hundred years. In ancient time whales were captured in narrow fjords by nets and killed by poisoned arrows.

The modern small whale fishery, whaling from ships equipped with harpoon-guns, started in 1877 when the Scots began hunting the northern bottlenose whale, *Hyperoodon ampullatus* (Southwell 1884). The Scots were followed by Norwegian sealers who caught a few bottlenose in 1882. Bottlenose whaling developed into a separate industry, and in the 1890s over 60 Norwegian vessels caught an average of about 2500 whales per year. This fishery was finished by the end of the 1920s (Jonsgaard and Øynes 1952).

Whaling for minke (*Balaenoptera acutorostrata*) and other small whale species from small fishing vessels commenced off the Norwegian coast in the 1920s, and by the late 1930s, operations had spread all along the Norwegian coast (Jonsgaard 1962). Since 1938 the number of participating ships has been regulated by license system (Christensen 1975), and at present about 120 permits are issued each year. Approximately 100 vessels take part in the catch. No limitation of size or number of whales is enforced, and as stated by Jonsgaard (1962) such regulations are out of the question for practical reasons. However, time limits for the whaling season can be used, and in 1950 a closed season of 3 wk in July was enforced. In 1955 whaling in arctic waters north of 70°N was forbidden after June 30 (Jonsgaard 1962). In the 1974 season, specific time limits will be enforced in separate areas. South of 70°N and east of 44°W (Kap Farvel), the open season will be from April 15 to August 31 with a closed period of 3 wk in July. North of 70°N and east of 20°W (the Barents Sea and Svalbard) the season will be from May 1 to June 30. These dates also cover the waters south of 70°N and east of 25°E. West of 44°W (West Greenland) the season will open May 15 and close August 31, with a closed period of 3 wk in July.

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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In Norway the meat from baleen whales is used for human consumption, and about 2000 tons of minke whale meat is consumed every year. The meat from toothed whales is used for animal food.

Catch of Small Whales in North Atlantic by Different Nations

Whaling for small whales in the North Atlantic has been carried out mainly by Norway, Denmark, and Canada. Canada has banned commercial whaling on the Atlantic coast from 1973, except for whaling by coastal residents for small noncommercial species such as pilot and minke whales (Mitchell 1974). A small fishery for minke whales also exists in Iceland, but catch statistics are incomplete. Reported catches of the different species of small whales in each of the seasons from 1962 to 1973 are shown in Table 1 (from International Whaling Statistics).

Minke whales constitute the major part of Norwegian catches, and between 2000 and 2500 animals are caught per year. Catches have decreased, but during the last few years, the annual catch has been stable. The low catch in 1973 was caused by bad weather.

There has been some interest in bottlenose whales during the 1960s, but in the last two seasons the low prices of animal foods have made the catch unprofitable.

The Danish catches shown in Table 1 represent catches of pilot whales off the Faeroe Islands and local catches off Greenland. The pilot catches seem to be decreasing, while the minke catches off West Greenland have increased. The Canadian small whale fishery was mainly concerned with pilot whales off Newfoundland and white whales in Hudson Bay (Jonsgaard 1974). There also has been a small fishery for minke whales in the bays of Newfoundland (Mitchell 1974).

Expansion of Norwegian Whaling and Catches Outside Norwegian Coastal Waters

The expansion of Norwegian whaling started just before World War II, and as shown in Table 2, minke whales were caught off Svalbard and off the Shetland–Faeroe Islands in 1938 and 1939. Table 2 is based on the annual reports issued by Fangstkontoret, Fiskeridepartementet, Oslo. Areas represented are shown in Fig. 1. The expansion continued after the war, and in 1948 and 1949 the first vessels moved into eastern Icelandic waters. In the statistics these whales are tabulated under the Shetland–Faeroe area. From Svalbard the whalers moved into the Barents Sea in the same two seasons. Between 1949 and the early 1960s only a few small whales were caught off Iceland and mainly by vessels fishing for basking sharks (*Cetorhinus maximus*). Not until 1961 did some Norwegian whaling vessels move into the Jan Mayen area and northern Icelandic waters. In 1966 the first Norwegian whaler caught minke whales in the Denmark Strait. Two vessels visited West Greenland for first time in 1968 (only one of these caught five minke whales; Jonsgaard and Christensen 1968), and in 1969 five vessels moved into Canadian waters, mainly off Labrador. Whaling at Labrador was based upon the catches of bottlenose whales. Off Newfoundland Norwegian whalers have caught a few minke whales in three seasons: 1969, 1971, and 1972. In 1973 one vessel was in this area, but no whales were caught.

According to Jonsgaard (1974), the westward expansion was made possible because some new vessels had been introduced and some older ones had been enlarged. In 1960 the sum of the average size and average engine power of the vessels was 150, increasing to nearly 300 in 1970 (Jonsgaard 1974) and 333 in 1973. The expansion of the fishery, illustrated by the number of whales caught in each season in different areas outside Norwegian coastal waters, is shown in Table 2.

From 1946 to 1951 activities in Svalbard–Barents Sea area resulted in increasing catches of minke whales. From 1952 to 1961 the annual catches in this area were nearly constant, but from then on the catches decreased until 1971 when they increased again.

There was some variation in the year by year catches of minke whales at the Shetland–Faeroes, and from 1969 there seems to be a decreasing trend.

Whaling for minke whales off East Iceland and at Jan Mayen has been insignificant compared to the catches in other areas. Most of the minke whales have been taken in connection with whaling for bottlenose whales, or underway to whaling areas farther West.

The catches at West Iceland and East Greenland and catches off West Greenland appear to be constant, depending on the number of participating vessels. The effect of whaling upon the bottlenose whale is clearly demonstrated in Table 2. In 1962 the bottlenose whaling started north of Iceland and continued in East Iceland and Jan Mayen waters. After a few years the bottlenose was scarcely to be seen in these areas, and the vessels had to move into the Labrador Sea to catch this species. Off Svalbard the bottlenose whale seems to occur only periodically.

Norwegian whaling for other species of small

TABLE 1. Catches of different species of small whales in North Atlantic waters reported (by different nations) in each of the seasons 1962–73 (data from the Bureau of International Whaling Statistics).

Seasons		1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	Total
Nation	*Species*													
Norway	Minke	3286	3233	2732	2467	2153	2175	2733	2391	2308	2362	2650	2055	30545
	Bottlenose	321	267	307	692	340	264	384	485	535	213	17	3	3828
	Killer	124	90	77	104	161	36	86	231	257	70	28	1	1265
	Pilot	43	71	54	32	339	117	31	27	43	—	—	—	757
Denmark	Minke	58	—	—	195	273	258	344	263	197	189	145	—	1922
	Bottlenose	—	3	3	—	—	—	—	—	1	—	—	—	7
	Killer	—	—	—	1	2	—	2	1	1	3	—	—	10
	Pilot	1753	2194	1550	1738	1512	1979	1754	1395	388	1032	512	—	15807
	White whale	10	—	317	429	561	594	1250	978	1416	737	841	—	7133
	Narwhal	—	—	—	100	152	160	502	221	417	232	120	—	1904
	White-sided dolphin	—	—	—	—	—	—	—	—	2	—	—	—	2
	Common porpoise	—	—	—	919	946	1135	1531	1317	1184	1320	1047	—	9399
	Unspecified	—	—	1371	181	10	2	19	39	62	81	—	—	1765
Canada	Minke	50	18	54	41	28	41	—	50	86	73	97	—	538
	Bottlenose	40	22	14	6	—	5	—	—	—	—	—	—	87
	Killer	—	—	2	—	—	1	—	—	—	2	—	—	5
	Pilot	220	221	2849	1520	887	739	311	—	155	—	—	—	6902
	White whale	174	160	460	354	482	390	582	178	72	106	254	—	3212
	Narwhal	—	—	—	—	—	—	—	—	—	—	54	—	54
Iceland	Minke	—	—	—	—	—	—	—	—	—	—	35	—	35

TABLE 2. The number of small whales caught by Norwegian whalers in different areas of the North Atlantic outside Norwegian coastal waters, in 1938–73. (Abbreviations: M = minke whales, B = bottlenose whales, K = killer whales, P = pilot whales.)

	A Spitsbergen and Barents Sea				B Shetland and Faeroe Island				C East Iceland and Jan Mayen				D North and West Iceland and East Greenland				E West Greenland and Davis Strait				F Coast of Labrador				G Newfoundland waters			
Season	M	B	K	P	M	B	K	P	M	B	K	P	M	B	K	P	M	B	K	P	M	B	K	P	M	B	K	P
1938	94	—	3		13																							
1939	13	1	—	—	3																							
1940	1	—	—	—	—																							
1941–45	no whaling																											
1946	146	7	4	—	157	—	5																					
1947	140	23	1	—	232	—	6	3																				
1948	679	14	4	—	340	—	4	—																				
1949	1944	184	12	—	192	2	—	—																				
1950	542	16	—	—	15	1	1	—																				
1951	759	43	4	—	61	2	1	2																				
1952	1776	—	—	—	106	—	—	—	1	—	—	—	1	—	—	—												
1953	1031	17	1	—	51	—	—	—	—	—	—	—	—	—	—	—												
1954	1458	19	—	—	51	9	—	—	—	—	—	—	—	—	—	—												
1955	1613	82	2	—	170	—	—	—	1	1	7	—	15	—	—	6												
1956	1238	217	9	—	187	1	13	—	—	—	—	—	—	—	—	—												
1957	1377	92	2	—	298	24	7	42	1	—	6	—	1	—	—	—												
1958	1833	97	11	—	410	12	—	182	—	—	—	—	—	—	—	—												
1959	1355	69	24	—	465	—	22	52	—	—	—	—	—	1	10	116												
1960	1503	150	14	—	480	—	14	34	—	—	—	—	18	—	14	245												
1961	1374	49	11	—	301	1	19	17	78	9	6	8	55	—	18	117												
1962	1248	131	11	—	336	—	10	1	125	13	37	—	76	172	20	21												
1963	1168	83	15	—	292	—	10	—	72	7	10	10	81	141	8	38												
1964	357	64	5	—	311	—	—	10	147	64	34	—	122	165	13	40												
1965	720	3	6	—	269	—	17	—	157	471	34	—	100	215	21	—												
1966	873	4	5	—	195	5	6	12	42	200	52	—	196	126	36	317												
1967	661	12	—	—	107	—	10	—	43	225	6	—	315	25	10	114	—	—	—	—								
1968	819	184	2	—	292	4	5	—	33	156	7	—	593	38	18	29	5	—	—	—								
1969	812	150	3	—	341	—	—	—	20	77	7	—	181	19	32	24	158	—	—	—	9	231	—	—	6	—	—	—
1970	884	81	2	—	275	1	—	—	11	—	—	—	254	11	12	—	138	—	—	1	2	436	—	—	—	—	—	—
1971	1001	—	1	—	257	1	1	—	35	10	1	—	173	51	36	—	320	—	—	—	—	151	—	—	11	—	—	—
1972	1576	—	—	—	193	—	—	—	5	—	—	—	259	17	4	—	100	—	—	—	—	—	—	—	120	—	17	—
1973	1042	3	—	—	134	—	—	—	5	—	—	—	215	—	—	—	267	—	—	—	—	—	—	—	—	—	—	—
Total	30037	1795	152	—	6534	63	151	355	776	1233	207	18	2655	981	252	1067	988	—	—	1	11	818	—	—	137	—	17	—

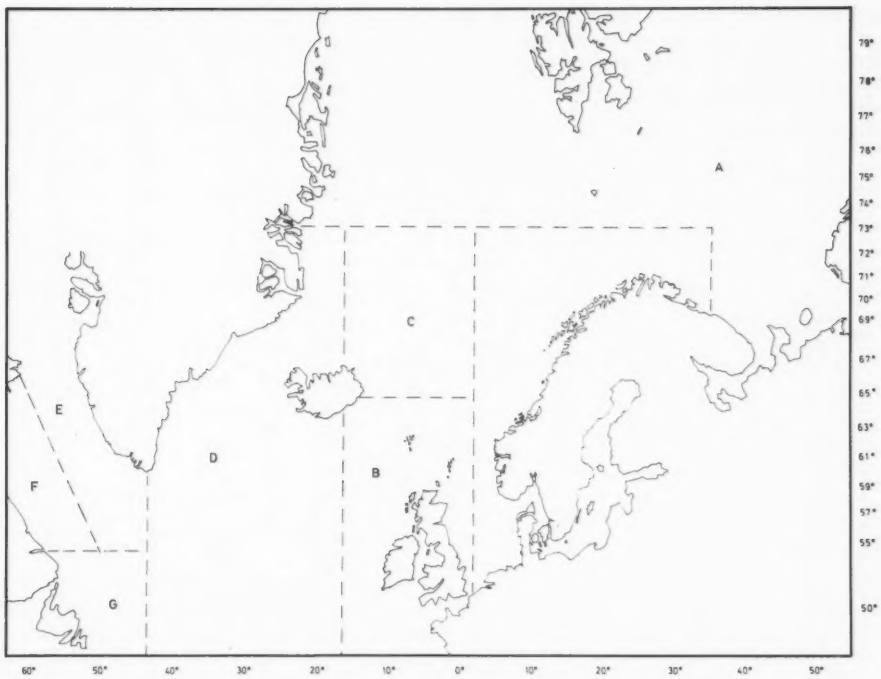

FIG. 1. Statistical areas used in Table 2. A) Svalbard and the Barents Sea, B) Shetland and Faeroe Islands, C) East Iceland and Jan Mayen, D) North Iceland, West Iceland, and East Greenland, E) West Greenland and the Davis Strait, F) Coast of Labrador, and G) Newfoundland waters.

whales is unimportant, and they are taken only as a supplementary catch.

Biological Research

Jonsgaard (1968) has reviewed Norwegian postwar publications on the biology of North Atlantic whales. Papers dealing with the biology of the small whales in the North Atlantic that have been published by Norwegian biologists since 1968 are listed below.

When whale research was taken up at the Institute of Marine Research, Bergen, in 1971, our initial effort was concentrated on the fishery for bottlenose whales in the Labrador Sea (Christensen 1971). A paper based on data from this investigation has been published (Christensen 1973), and a list of the data on length, age, weight of testes or ovaries, and the number of corpora are given in Tables 3a and 3b.

In the 1972 season two biologists collected biological material and data from 47 minke whales (17% males) caught in the Svalbard–Barents Sea area (Christensen 1972), and in the 1973 season material and data were collected from 120 minke whales (30% males) in the Barents Sea in May–June, 38 minke whales (66% males) off East Greenland in July–August, and 81 minke whales (15% males) off West Greenland from May to September. Some of the data were published elsewhere (Christensen 1974). Table 4 shows the number of animals sampled in 1973, and Fig. 2 and 3 show the areas where the whales were caught. The length frequencies of the minke whales examined in 1973 are shown in Fig. 4. The mean length in the Barents Sea was 702 cm for both sexes. Animals caught off West Greenland were bigger than animals in the Barents Sea, and the mean lengths in this area were 757 cm and 766 cm for females and males, respectively. In the material from East Greenland the mean lengths were 733 cm for females and 703 cm for males.

The difference between length-group frequencies (Fig. 4) and sex compositions (Table 4) indicate separate stocks of minke whales in the northeast

TABLE 3a. Female bottlenose whales examined off Labrador in 1971. A) Length in centimeters, B) age in years, C) mean length for each age-group, F) number of ovarian corpora, G) ovarian weight in grams, and H) mean ovarian weight in each age-group.

J. no.	A	B	C	F	G	H
110	534	2	534	0	31	31
7	605	3		0	49	
105	679	3		0	47	
111	576	3	620	0	29	41.7
116	638	4		0	17	
120	598	4		0	22	
8	650	4		0	34	
102	660	4		0	46	
114	630	4		0	36	
138	665	4		0	45	
140	669	4		0	35	
221	630	4	643	0	45	35.0
20	665	5		0	65	
136	670	5		0	44	
139	663	5		0	64	
148	679	5		0	46	
232	670	5	669	0	59	55.6
119	681	6		0	61	
154	706	6		0	69	
220	652	6	680	0	64	64.7
23	725	7		0	83	
123	680	7	703	0	70	76.5
26	713	8		0	65	
131	687	8	700	0	102	83.5
9	740	9		1	368	
22	760	9	750	0	140	254
14	715	10	715	1	130	130
112	718	11		1	269	
217	748	11		0	101	
218	734	11	733	1	84	151
16	735	12		2	326	
33	754	12	745	1	65	196
27	744	13		0	97	
29	784	13		3	346	
117	744	13		1	118	
137	746	13	755	1	151	178
1	760	14		1	116	
18	715	14		1	95	
227	770	14	748	1	103	105
19	717	15		3	124	
233	720	15	719	2	288	206
155	741	16		4	277	277
141	725	17		3	97	
35	775	18		3	155	
152	784	19		3	99	
58	742	20		6	194	194
34	779	21		7	489	
37	729	21		3	126	
101	720	21	743	5	339	318
151	770	22		7	440	440
24	783	23		4	124	124
145	762	24		5	279	
135	751	27		5	334	

and in the northwest Atlantic. The length distribution in the material from East Greenland was similar to the distribution in the Barents Sea, but the data are so few that no conclusions can be drawn with regard to the minke whales there.

Table 5 shows the number and percentage of sexually mature and pregnant females examined in the different areas in 1973. In the Barents Sea about 40% of the females were sexually mature, while off East and West Greenland about 70% were mature. Fertility seemed to be the same in all areas.

The length distributions of immature and mature females in the three areas in 1973 are shown in Table 6. The biggest immature females were between 750 and 774 cm long and the smallest mature females were between 700 and 724 cm. The mean length at sexual maturity was about 730 cm, and seemed to be the same both at West Greenland and in the Barents Sea.

The stomach contents of whales examined in the Barents Sea and off East Greenland consisted mainly of capelin. At West Greenland, sandeels and krill were the chief food items; only one whale had fed on capelin.

The sex compositions (Table 4) show that there was some segregation between males and females during the feeding migration. The females predominated in the Barents Sea and West Greenland samples, while males were most abundant in the catches off East Greenland. This segregation by sex was also shown by Jonsgaard (1951) and Christensen (1972) in the Barents Sea.

TABLE 3b. Male bottlenose whales examined off Labrador in 1971. A) Length in centimeters, B) age in years, C) mean length for each age-group, D) testis weight in grams, and E) mean testis weight in each age-group.

J. no.	A	B	C	D	E	J. no.	A	B	C	D	E
36	543	2		89		215	760	14		1180	
219	544	2		100		107	798	14	779	1340	1260
118	564	2		100							
113	573	2	556	200	122	5	775	15		837	
						32	872	15	824	1165	1001
134	625	3		120	120						
						125	773	16		860	
147	619	4		210		12	790	16		1414	
201	620	4		150		214	810	16		910	
202	625	4		140		21	810	16		1141	
126	626	4		110		206	820	16		1160	
146	631	4		120		226	835	16	806	1380	1144
122	684	4	634	120	142						
						211	800	17		1170	
203	620	5		120		229	810	17		990	
222	639	5	630	110	115	157	824	17		1090	
						156	844	17		1300	
3	685	6		159	159	17	864	17		1477	
						208	870	17		1590	
216	678	7		320		210	880	17		1530	
207	705	7	692	210	265	15	900	17	849	1456	1325
2	690	8		276		124	836	18		1550	1550
143	700	8		280							
212	720	8		710		6	822	19		1977	1977
225	740	8		220							
149	743	8		410		109	867	20		2390	
103	754	8		470							
13	820	8	738	730	442	128	812	22		1470	
						228	830	22		2300	
142	721	9		480		223	880	22	841	1310	1993
25	722	9	722	308	394						
						205	860	23		1380	
213	752	10		870		127	887	23	874	2260	1820
209	760	10		670							
121	766	10		920		129	829	24		1710	1710
153	780	10	765	620	770						
						150	833	25		2510	
231	785	11		760		230	845	25		1510	
204	800	11		830		106	860	25	846	490	1503
108	802	11	796	850	813						
						159	834	30		2620	
224	780	12		970		30	845	30	840	1678	2149
10	800	12		1113							
4	810	12		759		115	895	31		1900	
11	842	12	808	1160	1001	104	830	33	863	1140	1520
144	773	13		940		132	887	35		1800	1800
130	792	13		880							
31	798	13	788	1324	1048	133	798	38		2530	2530

Figure 5 shows the length-group frequencies of 75 females (mean length 735 cm) and 24 males (mean length 658 cm) examined by Jonsgaard in the Barents Sea in 1950, compared to the frequencies of 123 females (mean length 702.9 cm) and 44 males (mean length 698.4 cm) sampled in the same area in 1972 and 1973. This change in size from bigger to smaller females seems to support Jonsgaard's (1974) assumption that there may have been some overexploitation of minke whales in the northeastern arctic waters of the Atlantic. However, the time limits, the westward

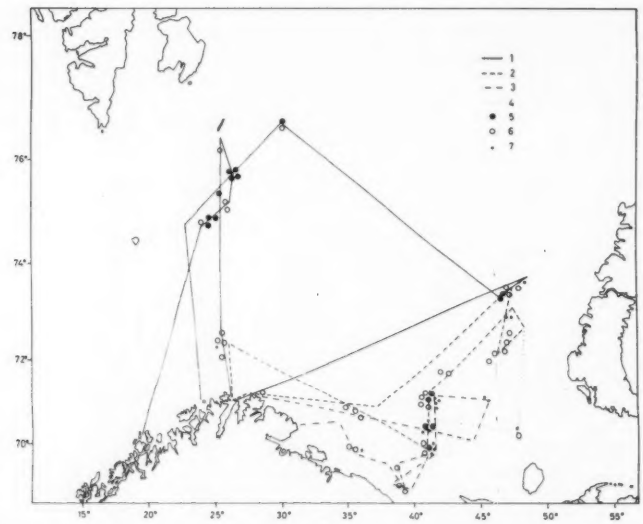

FIG. 2. Ship's tracks and whale sightings. 1) M/V *Riston*, 2) M/V *Asbjørn Selsbane*, 3) M/V *Svaløy*, and 4) M/V *Flid I* routes on the cruises to the Barents Sea in May–June 1973, and position of observed minke whales, 5) 25 whales, 6) 5 whales, 7) 1 whale.

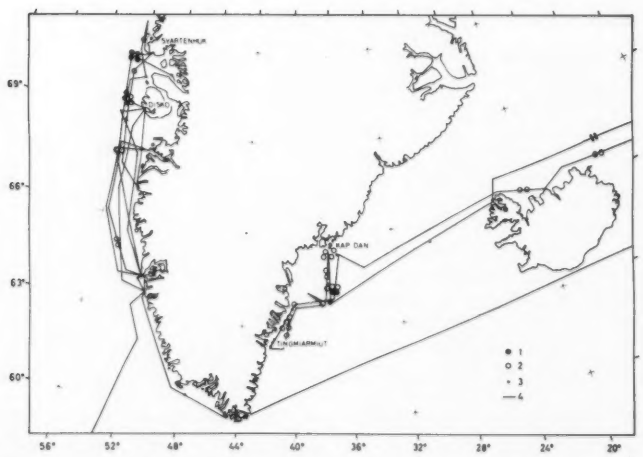

FIG. 3. Ship's tracks and whale sightings. M/V *Riston* and M/V *Vestfangst* respective routes to East and West Greenland in the summer 1973, and the position of observed minke whales. 1) 25 whales, 2) 5 whales, 3) 1 whale, 4) route.

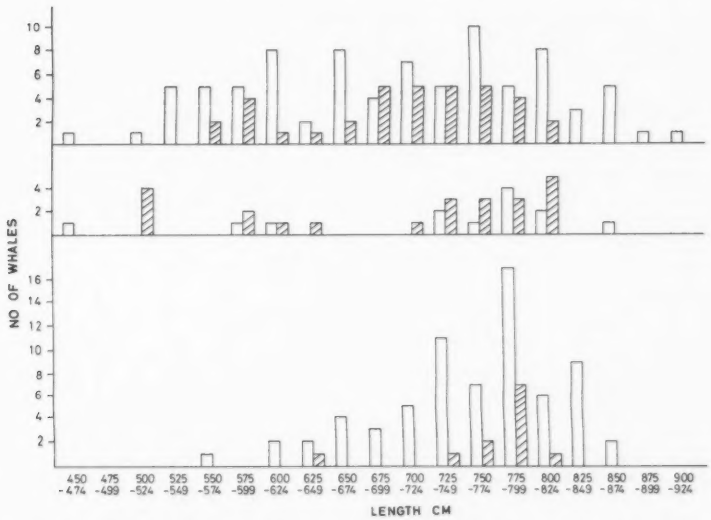

FIG. 4. Length-group frequencies of minke whales examined in the Barents Sea (*top*), off East Greenland (*in the middle*), and off West Greenland (*bottom*) in 1973. Open bars represent females, hatched bars represent males.

TABLE 4. Number and sex composition of minke whales examined in the spring and summer of 1973.

Area	No. examined	No. females	No. males	% females
Barents Sea	120	84	36	70.0
East Greenland	38	13	25	(34.2)
West Greenland	81	69	12	85.2
Total	239	166	73	69.5

TABLE 5. Sexually mature and pregnant female minke whales examined in 1973.

Area	No. females	Sexually mature		Pregnant	
		no.	%	no.	%
Barents Sea	84	34	40.5	33	97.1
East Greenland	13	9	69.2	9	(100.0)
West Greenland	69	49	71.0	44	89.8

expansion, and the reduced number of whaling permits issued evidently have affected the northeastern North Atlantic minke whale population in a positive way. These problems are being investigated, and a report based on the analysis of catch and effort data was presented for discussion at the June 1974 meeting of the International Whaling Commission (Solvik and Jonsgaard 1974).

A provisional analysis of catches per month, ship, and hunting day suggests that the present catch in the Barents Sea may be lower than the present sustainable yield of stock of minke whales

TABLE 6. Length distribution of sexually immature and mature female minke whales examined in different areas in 1973.

Area	Length group (*cm*) 450–474	475–499	500–524	525–549	550–574	575–599	600–624	625–649	650–674	675–699	700–724	725–749	750–774	775–799	800–824	825–849	850–874	875–899	900–924	Total
Barents Sea																				
No. immature	1		1	5	5	5	8	2	8	4	6	3	2							50
No. mature											1	2	8	5	8	3	5	1	1	34
East Greenland																				
No. immature	1					1	1					1								4
No. mature												1	1	4	2		1			9
West Greenland																				
No. immature					1		2	2	3	4	3	4	1							20
No. mature											3	6	6	17	6	9	2			49

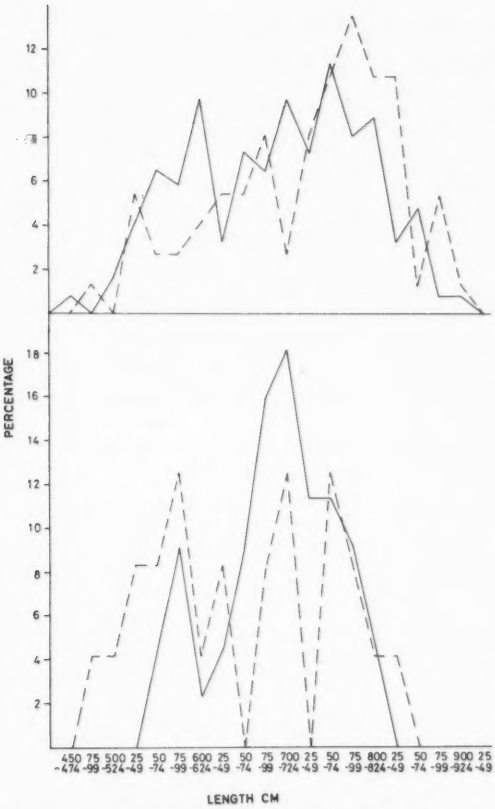

FIG. 5. Length-group frequencies of female (*top*) and male (*bottom*) minke whales in the Barents Sea. Data from the 1972 and 1973 investigations (solid lines) are compared to data collected in 1950 (dotted lines).

in this area. Figure 4 suggests an accumulated stock of minke whales off West Greenland.

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Relation Between Stranding Mortality and Population Abundance of Smaller Cetacea in the Northeast Atlantic Ocean[1]

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BROWN, S. G. 1975. Relation between stranding mortality and population abundance of smaller Cetacea in the northeast Atlantic Ocean. J. Fish. Res. Board Can. 32: 1095–1099.

The most complete and continuous series of stranding records is probably that for the British coasts, comprising 1616 strandings between 1913–72. The common or harbour porpoise (*Phocoena phocoena*) is most numerous (667 strandings, 41% of total), with 17 other species representing the remaining 59%. These data are related to sightings during two transatlantic yacht races, from a bird observatory off southwest Ireland, and from weather ships. The ratio of Irish sightings to strandings is at least 120:1, the ratio of sightings at weather ship stations to strandings of long-finned pilot whales (*Globicephala melaena*) is at least 150:1.

BROWN, S. G. 1975. Relation between stranding mortality and population abundance of smaller Cetacea in the northeast Atlantic Ocean. J. Fish. Res. Board Can. 32: 1095–1099.

La série continue la plus complète de records d'échouements est probablement celle de la côte anglaise, soit 1616 échouements de 1913 à 1972. Le marsouin (*Phocoena phocoena*) est le plus commun (667 échouements, 41% du total), la balance de 59% comprenant 17 autres espèces. Nous établissons la relation entre ces données et des observations faites lors de deux courses transatlantiques de yachts, depuis un poste d'observation d'oiseaux au large du sud-ouest de l'Irlande et sur des navires météorologiques. Le rapport entre les observations en Irlande et les échouements est d'au moins 120: 1; le rapport entre les observations sur les navires météorologiques et les échouements de globicéphales noirs (*Globicephala melaena*) est d'au moins 150:1.

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LITTLE work appears to have been done on the relationship between the numbers of individuals of any species of the smaller cetaceans stranded upon the coasts of a particular region, and the numbers of this species in the seas off these coasts. This relationship is presumably different for different species and will not be constant for any one species, but will vary with the nature of the coast and with short- or long-term changes in environmental factors such as coastal currents and water temperature. To examine the problem a reasonably complete series of stranding records for a species over a period of time, together with contemporary records of the numbers of the species at sea, are required. These are rarely available, which is no doubt the reason why this relationship has not been examined in any detail.

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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British Stranding Records and the Frequency of Stranding of Different Species

The most complete and continuous series of stranding records of cetaceans is probably that available at the British Museum (Natural History) which has operated a scheme for recording strandings on the British coasts since 1913 with the cooperation of Receivers of Wreck and H.M. Coastguard Service (see [Fraser] 1972). Under this scheme more than 1700 identified stranded animals of 22 species have been recorded to date.

Table 1 lists the numbers of strandings (not number of animals) in each decade from 1913 to 1972, the total number of strandings, and the percentage frequency of strandings for the 18 species of small cetaceans so far recorded on the British coasts. The scientific names of the species concerned are listed in Table 2. The number of strandings recorded in the 60-yr range from 667 (41% of the total) for the common porpoise to 1 for the white whale and pygmy sperm whale.

The frequencies of strandings provide some information about the relative abundance of the different species in British waters. On the assump-

TABLE 1. Strandings of small cetaceans on the British coasts in each decade for the years 1913–72.

	1913–1922	1923–1932	1933–1942	1943–1952	1953–1962	1963–1972	Total 1913–1972	Percentage frequency
Common porpoise	133	121	129	67	120	97	667	41
Bottlenose dolphin	20	31	42	28	38	38	197	12
Common dolphin	29	30	40	16	11	19	145	9
Minke whale	19	23	17	24	14	23	120	7
White-beaked dolphin	18	20	17	9	8	25	97	6
Pilot whale	6	8	7	14	24	30	89	6
Bottlenose whale	16	9	16	11	9	14	75	5
Risso's dolphin	7	11	21	16	5	10	70	4
Killer whale	4	8	7	8	5	13	45	3
Cuvier's whale	8	8	5	2	3	11	37	2
White-sided dolphin	5	7	5	3	2	10	32	2
Sowerby's whale	3	4	4	4	6	6	27	2
False killer whale	—	1	3	—	—	—	4	—
Euphrosyne dolphin	—	1	3	—	—	—	4	—
True's whale	1	1	1	—	—	—	3	—
Narwhal	—	—	—	2	—	—	2	—
White whale	—	1	—	—	—	—	1	—
Pigmy sperm whale	—	—	—	—	—	1	1	—

TABLE 2. English names of small cetaceans in British waters (Table 1 refers.)

Scientific name	Common name
Balaenoptera acutorostrata	Minke whale (Lesser Rorqual)
Mesoplodon bidens	Sowerby's beaked whale
Mesoplodon mirus	True's beaked whale
Ziphius cavirostris	Cuvier's beaked whale
Hyperoodon ampullatus	Northern bottlenose whale
Kogia breviceps	Pygmy sperm whale
Monodon monoceros	Narwhal
Delphinapterus leucas	White whale
Pseudorca crassidens	False killer whale
Globicephala melaena	Long-finned pilot whale, Caa'ing whale
Orcinus orca	Killer whale
Lagenorhynchus albirostris	White-beaked dolphin
Lagenorhynchus acutus	Atlantic white-sided dolphin
Tursiops truncatus	Bottlenose dolphin
Grampus griseus	Risso's dolphin
Stenella coeruleoalba	Striped (Euphrosyne) dolphin
Delphinus delphis	Common dolphin
Phocoena phocoena	Common or harbour porpoise

tion that strandings of the different species are all equally recorded and that in each species the number of strandings is directly proportional to the abundance of that species, the common porpoise is by far the most abundant species, followed by the bottlenose dolphin, about one-third as abundant, and then the common dolphin, minke whale, white-beaked dolphin, and pilot whale in descending order of abundance. The validity of these assumptions is, however, uncertain; for example, it is possible that some of the species are more prone to stranding than others. There appears to be little information on this question.

Sightings Records in British Waters

There are a number of scattered published sight records of various species of small cetaceans in British waters but very few series of records collected on a systematic basis. These latter are not very satis-

TABLE 3. Sightings of "dolphins and porpoises," and pilot whales, in Scottish waters east of 20° W long., and strandings of these two groups recorded on the British coasts in following months.

	No. of sightings	Estimated no. of animals	No. of strandings in following months[a]		
			3 mo	6 mo	12 mo
Dolphins and porpoises					
July 15–20, 1966	8	171+/197+ (184+)	5	9	22
July 18–22, 1968	23	429+/541+ (485+)	3	9	16
Pilot whales					
July 14–15, 1966	3	77/132 (105)	1	3	4
July 15–22, 1968	8	116+/142+ (129+)	—	1	3

[a]All strandings were of single animals.

factory because of the problem of accurate identification of most species at sea. Three series of records can be examined here.

SIGHTINGS DURING TWO TRANSATLANTIC YACHT RACES

In 1966 and 1968 the crews of yachts taking part in two transatlantic yacht races from Bermuda to Denmark and to Germany, around the north of Scotland, recorded sightings of cetaceans throughout their voyages (Boyde et al. 1968; Brown et al. 1971). Many of the records of small cetaceans were reported as "dolphins or porpoises" only, and all except four of the specific identifications by the observers must be regarded as tentative. For present purposes the records have been divided into two groups — "dolphins and porpoises," and pilot whales, in order to compare the numbers of these two groups sighted in the waters east of 20° W long. with the numbers of strandings recorded on the British coasts in the following months. All strandings of small cetaceans are included in the first group except pilot, killer, minke, and ziphioid whales.

In Table 3 the numbers of sightings and estimated total numbers of animals recorded for the two groups east of 20° W long. in July 1966 and July 1968 are given, together with the number of strandings (all of single animals) recorded on the whole of the British coasts in the following 3, 6, and 12 mo. In neither group is there any clear relationship between the estimated numbers seen at sea and the numbers of strandings recorded in the following months.

SIGHTINGS OFF THE SOUTHWEST COAST OF IRELAND

In the 8 yr 1959–66 during some 2200 h of watching for sea birds from the bird observatory at Cape Clear Island, 3030 cetaceans were recorded (Sharrock 1967). As with the yacht race sightings described above, specific identifications must be regarded as extremely tentative; about 20% of the total sightings were recorded only as dolphins/porpoises.

The sightings of small cetaceans, with identifications as recorded by the observers, are listed in Table 4 together with the stranding records for these species on the Irish coasts during the 9 yr 1959–67 inclusive (from O'Riordan 1972). Although the tentative nature of the specific identifications of the sightings must be borne in mind, it is evident that there is no clear relationship between the numbers of the different species reported sighted and their frequency of stranding in the same years. For example, common porpoises and pilot whales could be considered to be easier to identify at sea than some of the other species in the list. However, while more than 80 times as many common porpoises as pilot whales were sighted, the number of strandings of the two species was the same.

PILOT WHALES RECORDED AT NORTH ATLANTIC WEATHER SHIP STATIONS I AND J

During the years 1952–59, observers on weather ships at station I (59°N, 19°W) and station J (52° 30′N, 20°W) recorded cetaceans seen from the vessels as part of the scheme for recording observations of whales from ships operated by the National Institute of Oceanography with the cooperation of the Meteorological Office. A number of the records referred to pilot whales and those identifications that were supported by sketches, notes on behavior, etc. and could be considered as reliable have been published (Brown 1961).

In Table 5 the numbers of sightings and estimated numbers of pilot whales seen at the two stations in the period 1952–59 are compared with the numbers of strandings of the species recorded on the British coasts in the years 1952–60. Once again there is no clear correlation between the numbers of animals seen and the numbers stranded in the different years.

TABLE 4. Sightings of small cetaceans off Cape Clear Island 1959–66, and strandings on the Irish coasts 1959–67.

	Sightings		Strandings[a]		
	No. of animals	Percentage of total	No.	Percentage frequency	No. of animals
Dolphins and porpoises	603	20			
Unidentified dolphins	570	19			
Common porpoise	1421	48	5	20	5
Risso's dolphin	172	6	1?	4	1
White-sided dolphin	97	3	4	16	10
Killer whale	80	3	1?	4	1
Pilot whale	17	1	5	20	67
Common dolphin	10	—	1	4	1
Bottlenose whale	5	—	1	4	1
Cuvier's whale	2	—	3+2?	20	5
Bottlenose dolphin	2	—	1+1?	8	2
Total	2979		25		

[a]? = identity unconfirmed.

TABLE 5. Sightings of pilot whales from weather ship stations I and J 1952–59, and strandings on the British coasts 1952–60.

	No. of sightings			Estimated no. of animals			Strandings	
	I	J	Total	I	J	Total	No.	No. of animals
1952	3	1	4	155/270 (213)	20	175/290 (233)	Nil	Nil
1953	1	13	14	8	415+/490+ (453+)	423+/498+ (461+)	3	4
1954	4	1	5	110+/130+ (120+)	50/60 (55)	160+/190+ (175+)	Nil	Nil
1955	3	—	3	250+/300+ (275+)	—	250+/300+ (275+)	3	65
1956	3	3	6	75/95 (85)	25+	100+/120+ (110+)	4	5
1957	10	20	30	270/355 (313)	540+/590+ (565+)	810+/945+ (878+)	2	37
1958	1	4	5	30/50 (40)	185	215/235 (225)	Nil	Nil
1959	2	14	16	60/70 (65)	287+/298+ (293+)	347+/368+ (358+)	2	2
1960							4	4
Totals	27	56	83	958+/1278+ (1118+)	1522+/1668+ (1595+)	2480+/2946+ (2713+)	18	117

Conclusions

The records of sightings of small cetaceans in the waters around the British Isles are clearly inadequate at present to provide any useful comparison with the long series of stranding records available for the British coasts. It may be that systematic counts of animals over a period of years from a number of places such as Cape Clear Island could provide records that could be used to compare the relations between stranding mortality and population abundance. However, without much more reliable specific identifications of sightings, any such comparison would necessarily be limited to groups such as "small whales" or "dolphins and porpoises."

At this level of comparison, using the two series of sightings records that extend over the

number of years: (a) the sightings off Cape Clear Island suggest that the ratio of numbers of "small cetaceans" to strandings of this group on the Irish coasts is at least 120:1; (b) the records of pilot whales at weather ship stations I and J suggest that the ratio of numbers of pilot whales in the waters west of the British Isles to strandings on the British coasts is at least 150:1.

Acknowledgments

I am much indebted to Dr F. C. Fraser F.R.S. for access to his forthcoming report on strandings on the British coasts in the years 1948–1966 [Fraser 1974], and to Dr P. E. Purves for access to the unpublished records of these strandings for the years 1967–72.

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Long-Finned Pilot Whales, *Globicephala melaena*, driven ashore in Ireland, 1800–1973[1]

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O'RIORDAN, C. E. 1975. Long-finned pilot whales, *Globicephala melaena*, driven ashore in Ireland, 1800–1973. J. Fish. Res. Board Can. 32: 1101–1103.

Naturally occurring strandings or inshore migrations of pilot whales, *Globicephala melaena*, have been utilized on an opportunistic basis with yields of from 25 to approximately 300 animals. Single animals strand occasionally. Strandings or captures occur in all months except September. The commonest cetacean in Ireland is the common porpoise (*Phocoena phocoena*) but there is no fishery for it. It is sometimes entangled in nets. Commercial whaling from 1908 to 1923 took mainly fin whales and other species of large cetaceans. There has been no commercial whaling in Ireland subsequently.

O'RIORDAN, C. E. 1975. Long-finned pilot whales, *Globicephala melaena*, driven ashore in Ireland, 1800–1973. J. Fish. Res. Board Can. 32: 1101–1103.

On a profité des échouements naturels ou des migrations côtières du globicéphale noir, *Globicephala melaena*, avec rendements de 25 à approximativement 300 individus. Des individus isolés d'échouent occasionnellement. Il y a échouements ou captures à tous les mois de l'année, sauf septembre. Le cétacé le plus commun en Irlande est le marsouin *Phocoena phocoena*, mais on ne le pêche pas. Il s'empêtre parfois dans les filets. De 1908 à 1923, la chasse commerciale à la baleine a rapporté surtout des rorquals communs et autres espèces de grands cétacés. Il n'y eut aucune chasse commerciale en Irlande par la suite.

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ORGANIZED commercial whale fishing has seldom been carried on in Ireland. During the 19th century, however, attempts were frequently made to attack cetaceans whenever they appeared close inshore, or to drive them ashore and remove the flesh and blubber. The species taken in this fashion were most likely to be sperm whales, bottlenose whales, pilot whales, and the various species of dolphin.

The common porpoise (*Phocoena phocoena*) is the commonest of our cetaceans. There is no fishery for the species, and indeed, it is regarded as somewhat of a nuisance by fishermen in whose nets it becomes entangled. Captures and strandings of the porpoise are, for the most part, ignored and go unreported.

Commercial Whaling in Ireland

Two unsuccessful attempts were made to establish a commercial whale fishery on the Co. Donegal coast in the latter half of the 18th century. Though several whales were struck, few were captured. The expense of the operation was enormous and there was a lack of proper facilities ashore to reduce the blubber.

No further attempt was made until 1908 when the Arranmore Whaling Company established a shore-based factory on the South Inishkea Island, Co. Mayo. Shortly afterward a second company, the Blacksod Whaling Company, erected a station at Ardelly Point in Blacksod Bay, Co. Mayo, and commenced operations in 1910. Two whalers operated from each station, except in 1910 and 1911 when three were employed at Inishkea. They were manned by Norwegian crews, and the skilled labor ashore was likewise Norwegian. The local population provided unskilled labor. Most of the whales were believed to be taken in the summer months within a radius of 60–75 miles (95–120 km) off Inishkea.

Whale fishing ceased at the Inishkea Station in 1914 and the company discontinued business. Whaling at Blacksod was discontinued at the outbreak of World War I, but was resumed in 1920 and 1922. In 1923 the greater part of the station was burned down, and this, combined with a refusal on the part of the Norwegian bankers to continue financing the Company, caused it to

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TABLE 1. Statistics of whale catch and by-products, Inishkea and Blacksod stations, 1909–22. (Note: one barrel = 200 kg)

Station	Year	Whales landed	No. of whalers	No. of men in shore stations	Products				
					Oil barrels	Guano tons	Bonemeal tons	Cattle food tons	Whalebone tons
Inishkea	1908	77	2	—	—	—	—	—	—
Inishkea	1909	102	2	65	2900	53	120	124	14.5
Inishkea+ Blacksod	1910	120	5	60	3365	364	100	200	8
"	1911	131	5	80–90	4377	bags 2716	—	—	13
"	1912	60	4	60–70	2357	2562	—	—	2.75
"	1913	114	4	60–70	3900	4200 tons	—	—	4
Blacksod	1914	89	2	36	3304	226	—	—	9.2
"	1920	125	–	100	3995	298	—	—	12
"	1922	Figures not available							

cease operations. No commercial whaling has since been carried out in Ireland.

The catch and by-products are summarized in Table 1. More than two thirds of the total number of whales captured was *Balaenoptera physalus*. The catch of *Physeter catodon*, *Balaenoptera musculus*, and *B. borealis* Lesson amounted to about one tenth of the total in each case. Only a few *Megaptera novaeangliae* (Borowski) and *Balaena glacialis* Bonnaterre were taken. With regard to the smaller species, from the whalers' point of view a whale under 40 ft (12.2 m) was considered not worth chasing. Accordingly, no catch–effort data are available for the smaller species. The history of whaling in Ireland and details of catch and by-products from the whaling companies are given in a paper by Went (1968). Other information is derived from Moffat (1938), Burfield (1912), and Lillie (1910).

Pilot Whale Utilization

No commercial fishery for pilot whales (*Globicephala melaena*) exists or is known to have existed in Ireland. Accordingly we are dependent on occasional reports of isolated strandings for our knowledge regarding the occurrence and distribution of this species around the coast of Ireland. These reports may be published in the news media, or derived from correspondents, members of An Gárda Siochana (Civic Guard), fishermen, or the appropriate municipal authority. Pilot whales, because of their moderate size, are less likely to be overlooked than the smaller cetaceans.

The first recorded capture was that of 38 whales, believed to be pilot whales. A large school was observed off Curracloe on the east coast of Co. Wexford in July 1840. These were pursued by two (rowing) boats manned by willing and athletic hands, armed with guns, etc. The second shot took effect on one whale and it immediately uttered a fearful cry and rushed toward the Wexford bar followed by all its comrades. The pursuers continued firing and making much noise, and finally succeeded in driving them on shore near the Raven Point, where they made 38 captives. The captors later made themselves busy saving the blubber and other unctuous parts, for the purpose of extracting the oil.

In May 1844, a large shoal of whales entered Bantry Bay, on the west coast of Co. Cork, and found their way to Glengarriff Harbour a day later. All kinds of boats, weapons, and missiles were requisitioned for an attack on the herd. An estimated 300 whales were secured, and the value was computed at £1500.

In July 1851, a number of small whales was seen entering the Bay of Dunfanaghy, on the north coast of Co. Donegal. Boats were manned and means employed to drive the whales up the estuary. They were eventually stranded in a small bay above the town, assailed by a large number of people armed with muskets, axes etc., and were soon slaughtered. No fewer than 69 carcasses remained to reward the captors for the labor of the day.

About 25 specimens were captured in Dundrum Bay, Co. Down, in 1853. Over 100 yr elapsed before another large school was reported stranded. Thirty-six specimens were stranded at Fethard on the south coast of Co. Wexford in August 1957. Some of these were cut up by a manufacturer for animal meat and bone meal.

Finally, in November 1965, a school of whales was observed coming in on the rising tide in Brandon Bay, Co. Kerry. As the tide receded some were trapped on the sand in relatively shallow water. Many of the carcasses were cut up and sold to a firm interested in mink farming.

Single whales are stranded at irregular intervals, but it is only since Sir S. F. Harmer, of the British Museum initiated a scheme of systematic reporting in 1913, that any form of reliable information has been forthcoming (see Fraser 1953). From 1913 to 1945 five strandings of pilot whales were reported, one of which was doubtful. From 1956 to 1972 eleven strandings were reported, three of which involved more than one whale. Because of the likelihood that some strandings go unreported, either due to lack of interest or coming ashore on some remote beach, no firm conclusions can be drawn from the available data. However, the number of recent strandings might lend support to the view that there is no apparent decline in numbers of the pilot whale off the Irish coast. However, this view must be qualified by reports from other European maritime nations.

The following distribution table for pilot whales has been compiled from the list of strandings and captures from 1840 to 1972:

Ireland

East Coast: Co. Down 2, Co. Louth 1, Co. Dublin 1, Co. Wexford (E.) 2 TOTAL: 6

South Coast: Co. Wexford (S.) 1, Co. Waterford 1 TOTAL: 2

West Coast: Co. Cork (W.) 2, Co. Kerry 3, Co. Galway 2, Co. Mayo 2, Co. Sligo 2 TOTAL: 11

North Coast: Co. Donegal (N.) 3 TOTAL: 3

Harmer's and Fraser's British records (cited in Fraser 1953) from 1913 to 1947 mention inter alia strandings on the Welsh coast and in Devon and Cornwall. The above evidence is ample to indicate that the pilot whale visits the Atlantic coast of Ireland, St. George's Channel, and the Irish Sea.

Available records show that strandings or captures have occurred every month of the year except September. These occurrences seem more likely to occur in the spring and summer months.

Records of known strandings and captures of whales on the Irish coast are available in O'Riordan (1972). Accounts of the methods used by local fishermen in the 19th century to capture whales in inshore waters are given by Thompson (1849–1856).

BURFIELD, S. T. 1912. Belmullet Whaling Station — Report to the Committee. Rep. Brit. Assoc., Sect. D, Dundee 1912: 1–42.

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Dolphin and Small Whale Fisheries of the Caribbean and West Indies: Occurrence, History, and Catch Statistics — with Special Reference to the Lesser Antillean Island of St. Vincent[1]

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CALDWELL, D. K., AND M. C. CALDWELL. 1975. Dolphin and small whale fisheries of the Carribbean and West Indies: occurrence, history, and catch statistics — with special reference to the Lesser Antillean Island of St. Vincent. J. Fish. Res. Board Can. 32: 1105–1110.

Humpback whaling, and fishing for smaller cetaceans in the West Indies and Caribbean is on the decline, mainly due to economic factors. These factors are summarized. Catch statistics are tabulated for pilot, killer, false killer, and sperm whales, along with landed weight for mixed catches of dolphins. The pilot whale fishery of St. Vincent has taken 2912 blackfish (*Globicephala macrorhynchus*) in the period 1962–74 (mean 224 per annum). Catches occur in all months, but are lowest in December and January. Ten other species of smaller cetaceans known to be taken in the waters of St. Vincent are listed.

CALDWELL, D. K., AND M. C. CALDWELL. 1975. Dolphin and small whale fisheries of the Caribbean and West Indies: occurrence, history, and catch statistics — with special reference to the Lesser Antillean Island of St. Vincent. J. Fish. Res. Board Can. 32: 1105–1110.

La chasse de la jubarte et la pêche des petits cétacés aux Indes Occidentales et aux Caraïbes sont en voie de diminution, en grande partie à cause de facteurs économiques. Nous résumons ces facteurs. Nous donnons les statistiques de prises de globicéphales, orques, faux orques, cachalots, ainsi que le poids au débarquement de prises mixtes de dauphins. La pêcherie de globicéphales de St. Vincent captura 2912 *Globicephala macrorhynchus* durant la période 1962–74 (une moyenne de 224 par année). Les captures se font à tous les mois de l'année, mais sont à leur plus bas en décembre et janvier. Nous donnons une liste de dix autres espèces de petits cétacés de capture connue dans les eaux de St. Vincent.

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AN earlier report (Caldwell and Caldwell 1971a) outlined the history of whaling in the southern Caribbean and Lesser Antilles. It discussed fisheries for both the humpback whale, *Megaptera novaeangliae* (Borowski) and the smaller Cetacea, with emphasis on the short-finned pilot whale or blackfish, *Globicephala macrorhychus* Gray. The two kinds of whaling are not undertaken by the same fishermen, even though their home bases may be in sight of one another and the boats sometimes meet at sea. An example of this is the humpback whaling at Bequia (in the St. Vincent Grenadines in sight of the island of St. Vincent) and the blackfishing at St. Vincent.

The humpback whaling at Bequia is the last for this species in the West Indies. The fishery is almost extinct, being carried out only by a few of the hardier older men of the island, mostly as a test of skill. In recent years only one or two whales have been taken, and in some years none have been captured. When meat from this fishery is too much for local consumption on Bequia, it finds the same market in Kingstown, St. Vincent, as the St. Vincent blackfish meat. In both instances the meat is dried ("corned") to make it last longer without spoiling in the tropical heat. Both kinds of dried meat are usually sold in a small bundle that includes several strips of unrendered blubber intermixed with the strips of dried meat. Oil from the two fisheries is often exported as cooking oil, primarily to Trinidad, but also to Barbados and Grenada. Adams (1971) has provided a good summary of the Bequia whaling, and Dr H. E. Winn of the University of Rhode Island is gathering data on the fishery in a study of the humpback whale in the west North Atlantic.

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Earlier (Caldwell and Caldwell 1971a), we concentrated on the blackfishing at St. Vincent, the fishery with which we were most familiar, and listed known localities of fishing for blackfish and other species in the southern Caribbean. That list is still valid, as we know of no whaling for any cetacean species in the Greater Antilles or western Caribbean. Neither do we know of any high-seas whaling by any nation in the Caribbean or West Indies. A few dolphins are captured in the southeastern Caribbean incidental to fin-fish fisheries (Caldwell and Caldwell 1971a). Less detailed descriptions and data on the St. Vincent blackfishing also appear in Caldwell et al. (1971) and Caldwell (1972). Rathjen and Sullivan (1970) have provided a popular account of West Indian whaling, also based primarily on the St. Vincent blackfish industry.

Present Status of St. Vincent Blackfishing

The fishery at St. Vincent, centering at the leeward town of Barrouallie, is on the decline. This is not due to a lack of animals or loss of local markets. The decline is a combination of a reduced interest by potential fishermen (which started perhaps a decade ago), general world inflation, the world energy crisis, and the recently enacted U.S. Marine Mammal Protection Act of 1972.

Although only one blackfish boat had been converted to engine power when we first visited Barrouallie in early 1968, by 1972 all of the boats had been converted. For a time the more "efficient" motorized boats (efficient only in that they could range farther and faster in the hunt and return their heavy catch with greater ease — not in their ability to catch blackfish) offset the reduction in the numbers of boats fishing because of the reduced interest by the men in going to sea. Also, the motorized boats usually carry one less crewman and that helped offset the reduced labor force. By ranging farther and faster the catch per boat increased for a time so that the overall landings did not show a marked decline even with fewer boats fishing. However, other factors soon became important.

First, the blackfish began to run or dive away from the catcher boats before the boats could approach close enough to attempt a capture. Delphinids seem to learn the sounds of boats that spell danger very quickly, and avoid them while not running from other boats. Dolphin catchers in Florida, for example, often had to change their areas of operation because their boats soon became known by local populations. The men at St. Vincent could not simply "run down" the blackfish with faster boats, and this species does not ride the bow as do many of the small dolphin species that the Vincentians also hunt. The blackfish would sometimes dive rather than run, and the boats would pass them before they could turn, as the men once could with sailing boats. Even with this knowledge of the comparative behavior of the blackfish toward motor and sailboats, the whalemen did not want to resume the use of sail (although reduced sail is carried for emergencies) as it would mean more physical labor in fishing. They have been reluctant to do this, although it has been considered recently in light of high costs of fuel and engine parts.

A major problem was the loss of income from the sale of the high-grade melon oil that a New England importer purchased as an ingredient in fine instrument lubricants. While the amounts of oil were relatively small when one considers other kinds of whaling (150–200 gallons per year at most), the cash received for it (probably no more than U.S. $1500.00 even in a "good" year) was important to the economy of the town and to the operation of the fishery. Most of the so-called "body oil" is consumed locally as cooking oil or is shipped to other islands where it brings a much lower price than the "head" (melon) oil. The loss of the melon oil as an export commodity was the result of the passage of the U.S. Marine Mammal Protection Act of 1972 which prohibits the import of such products into the United States. The loss of this market has resulted in a wasted resource, inasmuch as the fishery has and will continue for the much needed meat that it provides. Any melon oil that is rendered is now mixed with the lower grade (and priced) body oil. Some oil of both types is used by the Vincentians as a patent medicine for colds and bronchitis.

Another problem for the fishery is the increased cost of equipment and other supplies. This, together with the high import duties imposed by the Vincentian government, makes operating almost prohibitive for the whalemen. The costs for repairs and supplies (ammunition, rope, sail, etc.) have soared above the income that the whalemen can expect to realize from the sale of their products in the local markets. Fuel is difficult to obtain at this time, and the cost of that available is over double that in the past year and a half. Some of the men are simply unable to go to sea because of these costs, even with a return to sail.

All of these factors have acted and continued to interact, causing an almost complete shutdown of St. Vincent blackfishing toward the end of 1974. By December 1973, there was even less blackfishing than usual with the normal holiday

TABLE 1. Numbers of blackfish landed at the port of Barrouallie, St. Vincent, for the 13 yr from 1962 through 1974. Data from the Barrouallie Fishermen's Cooperative Society. See text for variables affecting seasonal and annual distributions.

Month	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total	Avg
Jan.	6	9	8	15	8	6	28	4	10	9	12	5	0[e]	120[c]	10.0[c]
Feb.	7	15	37	18	5	35	85	12	15	33	8	5	2	277	21.3
Mar.	11	32	17	19	7	15	12	6	12	2	10	5	0[e]	148[c]	12.3[c]
Apr.	6	32	42	12	46	24	49	12	21	0	13	11	0[e]	268[c]	22.3[c]
May	5	57	9	22	50	41	40	53	55	18	8	0	15	373	28.7
June	15	80	48	12	41	53	21	50	28	0	11	10	3	372	28.6
July	7	70	11	18	7	21	25	12[a]	27	0	17	27	7	249	19.2
Aug.	2	31	20	27	12	14	48	?[b]	5	6	18	2	2	187[c]	15.6[c]
Sept.	4	55	43	24	67	16	27	?[b]	22	31	23	28	6	346[c]	28.8[c]
Oct.	4	33	26	9	30	24	44	?[b]	14	10	5	27	37	263[c]	21.9[c]
Nov.	25	10	7	4	40	17	2	24	23	40	23	29	14	258	19.8
Dec.	5	1	7	3	10	3	6	3	0	4	7	2	0	51	3.9
Totals	97	425	275	183	323	269	387	176[d]	232	153	155	151	86	2912	

[a]No records kept after July 8, but blackfish taken later in month.
[b]No records kept, but blackfish taken.
[c]Based on landings for 12 yr only.
[d]Year incomplete.
[e]No blackfishing conducted. At other times when no blackfish were reported, as in 1971, 1973, and 1974, the boats were fishing and usually brought in other cetacean species but failed to catch blackfish.

layoffs. There was no whaling in January, March, or April of 1974, and only one boat worked in February of that year to catch two blackfish. As the blackfish boats were beached for repairs and economic reasons, we presume that the few dolphins landed during these months (Table 3) were obtained by other boats which do on occasion catch dolphins for the fresh-meat market incidental to finfish fishing. On this meat-starved island this reduced dolphin catch, as well as the loss of the blackfish meat, may represent a major dietary problem. By May of 1974, blackfishing had resumed, with from one to four boats fishing for the rest of the year.

We have had no personal experience on the adjacent island of St. Lucia where there is also a significant amount of blackfishing. The blackfishing on that island is a direct outgrowth of the fishery at St. Vincent. Fishermen from the two islands sometimes meet at sea, and in bad weather may come to the shelter of port on the other island. The techniques of fishing and the catch composition of the two fisheries are similar. The present-day problems are apparently also similar. Aspects of the St. Lucia blackfishing are being examined by Dr D. E. Gaskin of the University of Guelph and his colleagues. Results so far published (Gaskin et al. 1974) deal with chlorinated hydrocarbon residues and heavy metals in tissues from specimens of *Globicephala macrorhynchus* and *Stenella* cf. *S. longirostris* Gray.

Composition of the St. Vincent Catch

The primary quarry of the Vincentians is the blackfish (Caldwell and Erdman 1963; Caldwell et al. 1971; Caldwell and Caldwell 1971a; Caldwell 1972). However, the whalemen frequently encounter the killer whale, *Orcinus orca*, the false killer whale, *Pseudorca crassidens*, and small sperm whales, *Physeter catodon* Linnaeus (see, for example, Caldwell et al. 1971; Caldwell 1972). Killer whales taken in this fishery provided the first record of a sea turtle as a food item for this species (Caldwell and Caldwell 1969).

The Vincentian whalemen pursue any cetacean species (excluding baleen whales) that they see, and consequently species are taken that even they consider exotic. These include: the pygmy killer whale, *Feresa attenuata* (see Caldwell and Caldwell 1971b; Caldwell et al. 1971); the dwarf sperm whale, *Kogia simus* (see Caldwell et al. 1973); the goosebeaked or Cuvier's beaked whale, *Ziphius cavirostris* (see Caldwell et al. 1971; Caldwell, 1972); the rough-toothed dolphin, *Steno bredanensis*; the Risso's dolphin, *Grampus griseus*; the Atlantic bottlenose dolphin, *Tursiops truncatus*; the spinner dolphin, *Stenella longirostris*; and the bridled dolphin, *Stenella* cf *S. frontalis* (G. Cuvier) (see Caldwell et al. 1971). While they do not chase humpback whales, the Vincentians see them close in to the island. If the fishery continues, we will learn of any other species taken as we have an associate on the

TABLE 2. Numbers of small sperm whales (SW), killer whales (KW), and false killer whales (FKW) landed at the port of Barrouallie, St. Vincent. Data from the Barrouallie Fishermen's Cooperative Society.

	1967	1968		1969			1970			1971			1972			1973			1974		
Month	SW	SW	KW	SW	KW	FKW	SW	KW	FKW	SW	KW	FKW	SW	KW	FKW	SW	KW	FKW	SW	KW	FKW
Jan.				2									1			1					
Feb.						5															
Mar.						3															
Apr.	3			2								1									
May		1	3								3				1					1	
June					4									1							
July			3								9							1			
Aug.																					
Sept.									2												
Oct.															1						
Nov.																		3			
Dec.						7															

TABLE 3. Dolphin ("porpoise") landed for food at the port of Kingstown, St. Vincent. Values are in pounds, as originally reported, with conversions to the nearest kilogram in parentheses. Data from the Kingstown fish market. Blank areas indicate no reports, rather than no fishing.

	1972	1973	1974
Jan.		419(190)	200(91)
Feb	1,711(776)	1,047(475)	500(227)
Mar.		1,018(462)	71(32)
Apr.	1,845(837)	3,204(1453)	
May	1,466(665)		
June	215(98)		
July	2,426(1100)		
Aug.	1,262(572)		
Sept.			
Oct.	2,507(1137)		
Nov.	893(405)		
Dec.		557(253)	
Totals	12,325(5590)	6,245(2833)	771(350)

island. On August 10, 1973, the whalemen encountered three *Kogia* sp. (which they call "rat porpoise") and captured a 9½-ft (2.9-m) female. The size of this individual (probably measured to tip of flukes rather than to notch) is at the maximum for *K. simus* as indicated by Handley (1966), and on the basis of size might be *K. breviceps* (Blainville), which the fishermen would not likely distinguish from *K. simus*. No specimen was saved and the whalemen did not say if the two animals that escaped were larger or not.

Catch statistics for blackfish are available from the Barrouallie Fishermen's Cooperative Society in some detail. They are here summarized (from Caldwell et al. 1971) and updated for an additional 4 yr (Table 1). More limited landing data are available for false killer whales, killer whales, and small sperm whales (Table 2). Those especially for the latter two species show a trend toward seasonality of capture (and hence occurrence). Although some of the factors affecting seasonality in blackfish landings also apply to these three species, they are more complex for the blackfish (see Summary and footnotes to Table 1).

While landing data on the larger species captured are kept segregated at Barrouallie, most of the smaller species taken are lumped by weight under the heading of "porpoise." In a given month there is no way to tell which species or how many individuals were included in these landings. Spinner and bridled dolphins apparently make up the bulk of the dolphin catch. The smaller dolphins are usually taken for fresh meat only, and generally are not landed at Barrouallie where there is no refrigeration, but taken directly to the Kingstown fish market. From the proprietor of that market we have some data on total weights of dolphins landed there for 16 mo between February 1972, and March 1974 (Table 3). These landings were made after all boats were fitted with engines. Since most of the dolphins landed were species that ride the bow of even these small boats, thereby becoming prey to hand harpoons, these landings might be considered representative of especially "good" years. In 16 mo of successful fishing over a 2½-yr period, only 19,341 lb (8773 kg) were landed, and at a conservative estimate of 80 lb (about 36 kg) per animal for the small spinner dolphins that comprise much of the catch, the total taken would be only 242 dolphins. Inasmuch as individuals of larger species (double or more this weight) are included, the number taken was probably considerably lower. Even doubling this conservative value for unreported months (see Table 3), the maximum number of several species of dolphins would have a combined total of less than 500 individuals over the 2½-yr period. From their subjective observations, the fishermen tell us that they have seen no decline in the populations of any species.

Discussion and Summary

The gradual decline in the catches of blackfish (Table 1) can be explained through factors other than overfishing. These include loss of export market, increased cost of operation, and lessening of interest by potential new fishermen. Although there appear to be seasonal trends in the numbers of blackfish in Vincentian waters, these apparent trends are overshadowed to a large degree by

factors such as weather (the fishermen do not set out in bad weather, but may be trapped by it at sea), seasonal holidays, number of boats operating for varied reasons, and the kinds of boats operating (sail or motor). There is no evidence from observations made in the islands that there is a decline in numbers of blackfish available to the fishermen as compared with previous years. The fishing pressure is so small that it seems unlikely that any management procedures are presently required.

The same is true for the dolphin fishing conducted by the same whalemen as an adjunct to the blackfishing. Fishing pressures are small relative to the available stocks, and the pressure on any one species is even less significant when the number of species available for exploitation is compared to the total weight of this mixed group that is landed.

Acknowledgments

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Review of Japanese small-type whaling[1]

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OHSUMI, S. 1975. Review of Japanese small-type whaling. J. Fish Res. Board Can. 32: 1111–1121.

A review is given of Japanese whaling operations taking small whales with catcher boats of approximately 40 tons and mounting cannons of 50-mm bore and under. Main species caught are minke, Baird's beaked, pilot, and killer whales. The catch of minke whales peaked at 532 in 1956, and has ranged between 220 and 365 annually since 1959. Decreases have been seen in catches of Baird's, pilot, and killer whales. Catcher efficiency may have changed.

OHSUMI, S. 1975. Review of Japanese small-type whaling. J. Fish. Res. Board Can. 32: 1111–1121.

L'auteur fait la revue des opérations japonaises de capture de petites baleines à l'aide de chasseurs d'environ 40 tonnes portant des canons de 50 mm de calibre ou moins. Les principales espèces capturées sont le petit rorqual, le bérardidé de Baird, le globicéphale et l'orque. Les prises de petits rorquals atteignirent un sommet de 532 en 1956 et, depuis 1959, ont varié entre 220 et 365 annuellement. On constate des diminutions chez les bérardidés, les globicéphales et les orques. L'efficacité des chasseurs peut avoir change.

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JAPANESE coastal cetacean fisheries are divided into three categories for the convenience of administration: large-type whaling, small-type whaling, and local fisheries. The first two are the fisheries catching whales using powered vessels with mounted harpoon guns, and licensed by the Minister of Agriculture and Forestry of the Japanese Government. They are further divided into two categories according to their objective: one is for larger species such as baleen whales (excluding the minke whale) and the sperm whale, and the other for middle-sized whales such as minke, beaked, killer, and pilot whales.

Several papers were published on small-type whaling in Japan and on the biological studies on some species caught by this type of whaling. Matsuura (1943a, b) and Japan Whaling Association (1944) reviewed the development and status of small-type whaling during World War II. Maeda and Teraoka (1952), Omura et al (1953), and Japan Whaling Association (1954) reviewed the status of whaling after the end of the War. The Fisheries Agency noted the annual status of whaling Yearbooks of Japanese Fisheries, 1954–1966). The Fisheries Agency (1965) also reviewed small-type whaling briefly. Catch statistics of small-type whaling have been published in the Annual Report of Catch Statistics on Fisheries and Aquaculture from the Statistics and Survey Division of the Ministry of Agriculture and Forestry. They have been also included in the International Whaling Statistics since 1954.

Matsuura (1936) and Omura and Sakiura (1956) reported on minke whales in the waters adjacent to Japan. Omura et al. (1955) and Nishiwaki and Oguro (1971) reported on Baird's beaked whale, and the former authors also included notes on Cuvier's beaked whale. Matsuura (1938) and Nishiwaki and Handa (1958) reported on killer whales. The materials for these reports were mostly obtained from catch records of small-type whaling in Japan. Nishiwaki (1965, 1967) published monographs on marine mammals, and included descriptions of the whales caught in small-type whaling activities in Japan.

In the present paper, I would like to describe briefly Japanese small-type whaling, with special reference to the catches from 1948 to 1972. I use this data base to examine the present status of the cetacean resources, and to discuss the establishment of future research systems for population studies of middle-sized whales in the waters adjacent to Japan.

History

Yamase (1760) noted 14 cetacean species, including Baird's beaked, killer, and three kinds of pilot whales caught in Japan. Baird's beaked whale (*Berardius bairdii*) has been caught in Chiba prefecture since the early years of the 17th century (Omura et al. 1955; Komaki 1969). Traditional whaling flourished on the

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TABLE 1. Small-type whaling catcher boats in 1972.

Name	Tonnage	Engine	Year built	Gun	Crew	Operator
Ginseimaru No. 2	28.21	D. 220 HP	Dec. 1957	50 mm	7	Mr. I Miyoshi
Kihohmaru No. 5	29.82	D. 220 "	Feb. 1960	"	7	Aoshima Suisan Co.
Taishomaru	42.35	D. 400 "	Apr. 1965	"	9	Seiyo Gyogyo Co.
Taishomaru No. 2	45.39	D. 340 "	June 1965	"	7	Nihon Sui. Kag. Co.
Koeimaru No. 7	36.65	D. 340 "	May 1971	"	8	Mr. Toba, Y.
Sumimaru No. 5[a]	47.96	D. 270 "	Dec. 1970	"	—	Marujo Gyogyo Co.
Yasumaru No. 1	42.51	D. 400 "	Mar. 1966	"	7	Fuji Suisan Co.
Sumitomomaru No. 11	42.22	D. 400 "	Dec. 1965	"	8	Gaibo Hogei Co.
Kotobukimaru	45.34	D. 400 "	June 1963	"	7	Mitate Hogei Co.
Katsumaru	7.59	D. 65 "	Dec. 1970	25 mm[b]	4	Taiji Town

[a]Did not operate in 1972.
[b]Three harpooned gun.

western coasts of Japan. However, this traditional whaling, which used small boats and hand harpoons, was discontinued in most regions by the end of the 19th century. The Norwegian whaling method was introduced to take middle-sized whales, first in Chiba prefecture in 1908 (Matsuura 1943b). A peculiar type of five harpooned gun, which has been used mainly in Wakayama to take pilot whales, was imported from the United States around 1910 (Matsuura 1943a). The harpoon guns for taking middle-sized whales have been improved since then, and miniature types of ordinary modern whaling guns have been used since about 1935.

Small-type whaling to take minke (*Balaenoptera acutorostrata*), Baird's beaked (*Berardius bairdii*), killer (*Orcinus orca*), pilot whales (*Globicephala* spp.), and other smaller cetaceans developed gradually in Sanriku, Chiba, Wakayama, Shikoku, and Saga. The number of catcher boats increased to about 20 by the beginning of World War II. This type of whaling rapidly developed during the war to supply the demands for human consumption of whale meat, whale oil, and other products. According to the Japan Whaling Association (1944), 53 catcher boats were listed up to the end of 1942. At that time, small-type whaling was freely licensed, except in Chiba prefecture where the permission of the Governor was needed. There were seven catcher boats in this prefecture in 1943.

At the end of the war in 1945, many operators appeared in succession to take whales by means of small-type whaling to rehabilitate the food supply in Japan. It became necessary to regulate this whaling in order to control whale resources and whaling grounds. The Japanese Government established a license system through the Minister of Agriculture and Forestry under a ministerial ordinance on December 5, 1947. Since then, this type of fishery has been called formally "the small-type whaling" in Japan, and whalers have been obligated to operate under the many items of the ordinance.

The Small-Type Whaling Association requested that the government permit the taking of sperm whales, stimulated by the development of pelagic whaling in the North Pacific from 1954. In 1957, the Government gave the Association the opportunity to build a large-type whaling catcher boat and to join into a sperm whaling expedition in the North Pacific, under the condition that 64 small-type whaling catcher boats must be decreased to 25. Thus, 350 tons of the catcher boats were removed to build a large catcher boat, and *Taka-maru* was built in 1960. The transfer of tonnages of other small boats was permitted to increase the tonnages of large-type whaling boats in coastal whaling. Subsequently, small-type catcher boats gradually decreased to 23 by 1961.

The government also permitted the small-type whalers to convert to large-type coastal whaling; a company was established, and tonnages were equalized sufficiently to obtain a large catcher boat in 1968. Since then, the number of small-type catcher boats permitted by the government has diminished to 10.

Small-type Whaling Catcher Boats

The majority of operators of small-type whaling in Japan are individuals with small capital. The largest capital of an operator was only 10 million yen, even in 1972.

The size of small-type catcher boats was 5–10 tons in Chiba and Wakayama, and 15–20 tons in other regions, in wartime (Matsuura 1943b).

The average tonnage of the catcher boats has been increasing accompanying the decrease in number. For example, it was 14.67, 23.45, and 35.56 tons in 1952, 1962, and 1972, respectively. Until the 1950s, catcher boats ranged in size from 3.5 to 29 tons, 30 tons being the maximum size permitted. Policy then changed to permit the building of larger boats, up to 40 tons, if companies could gather sufficient tonnages for them in 1963. Recently, construction of boats 40 tons and over has been permitted by an act for the improvement of cabin capacity. Table 1 shows the catcher boats permitted in 1972, and the yearly change in the number of boats is shown in Table 2.

There have been many kinds of harpoon guns

TABLE 2. Number of whales caught by Japanese small-type whaling.

Year	Catcher boat		Number of whales					
	Number	Tonnage	Minke	Baird's	Pilot	Killer	Others	Total
1948	73	—	285	76	725	48	41	1175
1949	—	—	184	95	890	44	49	1262
1950	80	—	259	197	715	24	18	1213
1951	68	—	334	242	618	66	34	1294
1952	65	954	485	322	335	58	39	1239
1953	58	870	406	270	460	66	37	1239
1954	54	864	365	230	75	100	33	803
1955	47	776	427	258	61	85	40	871
1956	54	945	532	297	297	38	46	1210
1957	46	851	423	186	174	78	37	898
1958	35	683	512	229	197	73	178	1189
1959	32	657	280	186	144	36	391	1037
1960	25	525	253	147	168	48	178	794
1961	23	510	332	133	133	54	305	957
1962	20	469	238	145	80	47	377	887
1963	19	475	220	160	228	43	179	830
1964	18	446	301	189	217	99	434	1240
1965	17	522	334	172	288	169	71	1034
1966	18	542	365	171	199	137	220	1092
1967	17	522	285	107	237	101	294	1024
1968	10	338	239	117	166	22	274	818
1969	10	338	234	138	130	16	56	574
1970	9	313	320	113	152	12	29	626
1971	9	320	285	118	181	10	25	615
1972	9	320	341	86	91	3	17	538

used. The gun generally used is a miniature type of ordinary whaling-gun. In 1947, a 40-mm bore gun was permitted, and this limit was changed to 50 mm in 1952. Most of the recent catcher boats have a 50-mm bore whaling gun with a grenade harpoon. A peculiar type of 20-mm bore, five-harpooned gun was used in Wakayama until recent years, but it was changed to a 25-mm bore, three-harpooned gun in 1971.

Most catcher boats now have telegraph, telephone, radar, direction finder, and loran, but there are no boats that have an electronic whale chaser. Whalers have been using a motor boat in recent years to chase minke whales. About eight crew, including a gunner, are on board.

Catcher boats are small and have a short cruising range; the whaling ground is thus limited to within 100–150 miles from a land station. They are also dangerous to operate in bad weather, and often anchor in port on inclement days. Therefore, the catch efficiencies of small-type catcher boats are poorer than those of ordinary catcher boats.

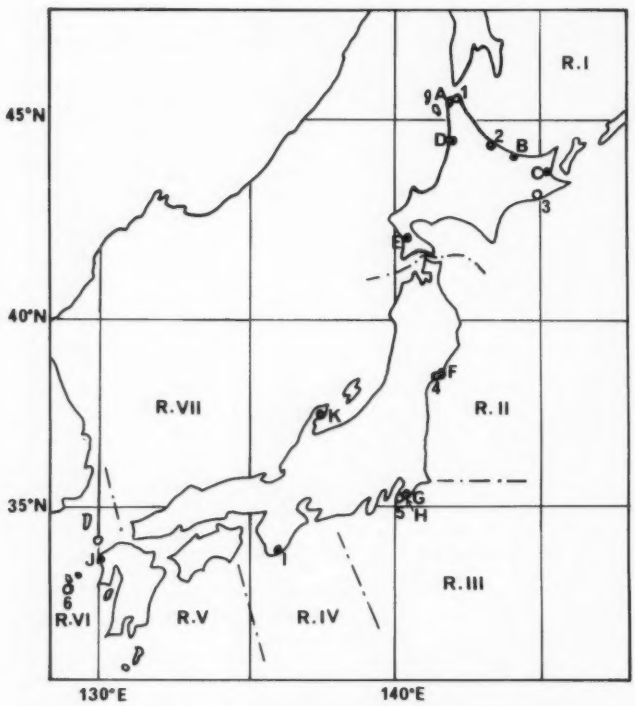
Land Stations

Many land stations for small-type whaling were distributed along the coasts of Japan. The number of land stations was 56, located in 36 shore bases in 1953 (Japan Whaling Association 1954). However, as the number of catcher boats declined, so did the number of stations. In 1972, only 13 stations, located in 11 shore bases, operated for the small-type whaling, although 19 stations in 14 shore bases were permitted by the government. Figure 1 shows the location of shore bases operating in 1972. These stations are small, and are meant only for small-type whaling. Some ordinary land stations for large-type whaling have also been used for small-type whaling in recent years. In 1972, seven ordinary land stations, located in six shore bases, were used for small-type whaling. A few catcher boats use the same land stations cooperatively.

Small-type whaling requires many land stations, for the catcher boats are small, and have a short cruising range. Also, whales are distributed widely and migrate seasonally. Thus, catcher boats must move widely and change land stations seasonally. A single catcher boat was used in eight stations in 1 yr, but this was an extreme case.

A small-type whaling land station has, in general, the following facilities:

Flensing facilities: Flensing deck, meat deck, meat tanks, winch, water pumps, etc.



Symbol	Shore-base	Station
A	Wakkanai	1
B	Abashiri	2
C	Shibetsu	1
D	Haboro	1
E	Otobe	1
F	Ayukawa	2
G	Wada	1
H	Shirahama	1
I	Taiji	1
J	Karatsu	1
K	Noto	1
1	Wakkanai	1
2	Mombetsu	1
3	Akkeshi	1
4	Ayukawa	2
5	Shirahama	1
6	Tamanoura	1

FIG. 1. Land stations for small-type whaling, operating in 1972, and division of regions. Closed circle, shore base, especially for small-type whaling; open circle, shore base for large-type whaling, also used for small-type whaling.

Oil facilities: Oil deck, cookers, oil tanks, cutter, motor, etc.

Fertilizer facilities: Cookers, fertilizer deck, chopper, etc.

Store houses: For fertilizer, toasted blubber, whaling gear, and materials.

Other: Office, dormitory, garage, etc.

In this paper, whaling areas are divided into the following regions. They are also shown in Fig. 1.

Region I: Hokkaido
Region II: Sanriku
Region III: Chiba
Region IV: Wakayama
Region V: Shikoku
Region VI: Kyushu
Region VII: Sea of Japan

Catch

CETACEAN SPECIES CAUGHT

The catching of baleen whales (except the minke) and the sperm whale, is legally banned in small-type whaling. The main objects of this whaling are minke, Baird's beaked, pilot, and killer whales. Cuvier's or goose-beaked whales (*Ziphius cavirostris*) are occasionally caught. Species of *Mesoplodon*, *Grampus*, *Pseudorca*, or *Feresa* are also rarely caught. Dolphins and porpoises are sometimes taken by whalers, but they are caught with hand darts. In this paper, the species caught are separated into five categories: minke, Baird's beaked, pilot, killer, and other whales. At least two species of pilot whales are caught in the waters around Japan. According to Matsuura (1943b), *Globicephala melaena* is caught in Sanriku, and *G. macrorhynchus* is caught in the Wakayama area. However, all *Globicephala* species are included in "pilot whales" in this paper (and see Kasuya 1971). Some whalers separate "Kuro-tsuchi" from Tsuchi-kujira (*Berardius bairdii*), but we have not yet obtained any evidence of its identification, as Omura et al. (1955) have pointed out.

CATCH SIZE AND ITS YEARLY CHANGE

Good catch statistics are not available from before the establishment of government regula-

tion of the fishery from 1948. Matsuura (1936) showed the catch of minke whales around Japan in prewar times, and according to Matsuura (1943b), 22 minke, 24 Baird's beaked, 517 pilot, 15 killer, 6 unidentified whales, and about 150 dolphins were caught in Sanriku, Chiba, and Wakayama areas in 1941.

Table 2 and Figure 2 show the size of catch by species and by year from 1948 to 1972. Numbers and total tonnages of catcher boats operating are also shown. The number of catcher boats has gradually decreased from 80 in 1950 to 9 in recent years. The ratio of decrease of total tonnages is not as remarkable as that of the number of catcher boats, but this has decreased from about 1000 to 320 tons. The size of catches has decreased accompanying the decline in the number of catcher boats. For estimating the change in abundance of whale populations, the catch per unit of effort (CPUE) is considered a useful index of population density. The ideal measure of catch effort is the actual operation time corrected with catch efficiencies and with weather factors for each whale species. However, this kind of data has not been available. In the present paper, total tonnages is used as a measure of effort, since larger catcher boats are more efficient. CPUEs then represent a very simple index of population density.

Minke whale — The catch of minke whales increased gradually until 1956, when it reached 532. The catch has been almost constant (220–365 annually) since 1959, though the catcher boats have decreased in number. CPUE has been increasing, especially in recent years. Several factors could account for this phenomenon. The minke whale is economically the most valuable of the whales taken in the small-type whaling; actual efforts have been made to take it. It is necessary to obtain the effort, separated by whale species, to prove this. As noted above, motor boats have been used for taking minke whales in recent years and may increase catcher efficiency. Another reason might be increased abundance of the minke whale. There is no evidence, at least, to show any decline of population density in the minke whales around the Japanese coast.

Baird's beaked whale — The catch of this species has a tendency to decrease. It was 322 at its maximum in 1952. CPUE has been almost constant throughout the years 1952–72.

Pilot whales — Many of these whales were caught, even in prewar seasons. After the war, the fishery for these whales flourished until 1949, when 890 whales were caught. A sudden decrease in the catch has been observed since then. This is mainly caused by the decline in the number of small catcher boats that hunted mostly pilot whales. Since 1954, the catch has been constant, and CPUE has shown a tendency to increase. Catches are all *G. macrorhynchus*, but the possibility of occurrences of *G. melaena* in northern Japan needs study (T. Kasuya, personal communication).

Killer whale — The catch is relatively low, excluding years 1964–67, and has been gradually decreasing. Catches were extremely high in 1964–67. The CPUE has also gradually decreased. The reason for this must be examined in future.

Other cetaceans — Several species are included in this category. The annual catch was usually less than 60, but it was 71–434 during years 1958–68. Large catches include many dolphins. The usual catch was comprised mainly of the goose-beaked whale.

Locality of Catch

Catch statistics were obtained by species, by regions (which were listed in the discussion of land stations above), and by years. The composition of whale species is very different by regions. Figure 3 shows the species composition in each region, based on data in years 1948–72.

Region I — The dominant whale species caught in this region is the minke whale, and it comprises 72.1% of whales caught. Baird's beaked and killer whales comprise 11.7 and 10.0%, respectively. Catches of pilot and other whales are relatively small (5.7 and 0.6%, respectively). This region takes 20.6% of the total number of whales caught in the Japanese small whale fishery.

Region II — The catch size is largest in this region (38.2%). There is no dominant whale species, though minke and pilot whales comprise 38.2 and 30.5% of the catch, respectively. Catch ratios of Baird's beaked, killer, and others are 19.7, 6.9, and 4.7%, respectively.

Region III — This region has a long history of catching Baird's beaked whale, and this species is still dominant in catches (68.6%). The catch of minke whales is only 1.2% in this region. Catch ratios of pilot and killer whales are 9.8 and 2.8%, respectively. Most of the others are goose-beaked whales, and they comprise 17.6% of the total catch in this region. The total catch in this region is 11.2% of all whales caught in Japanese small-type whaling.

Region IV — Although this region has a long history of whaling, small-type whaling is not so prominent, compared with Regions I and II, because the valuable whale species such as minke

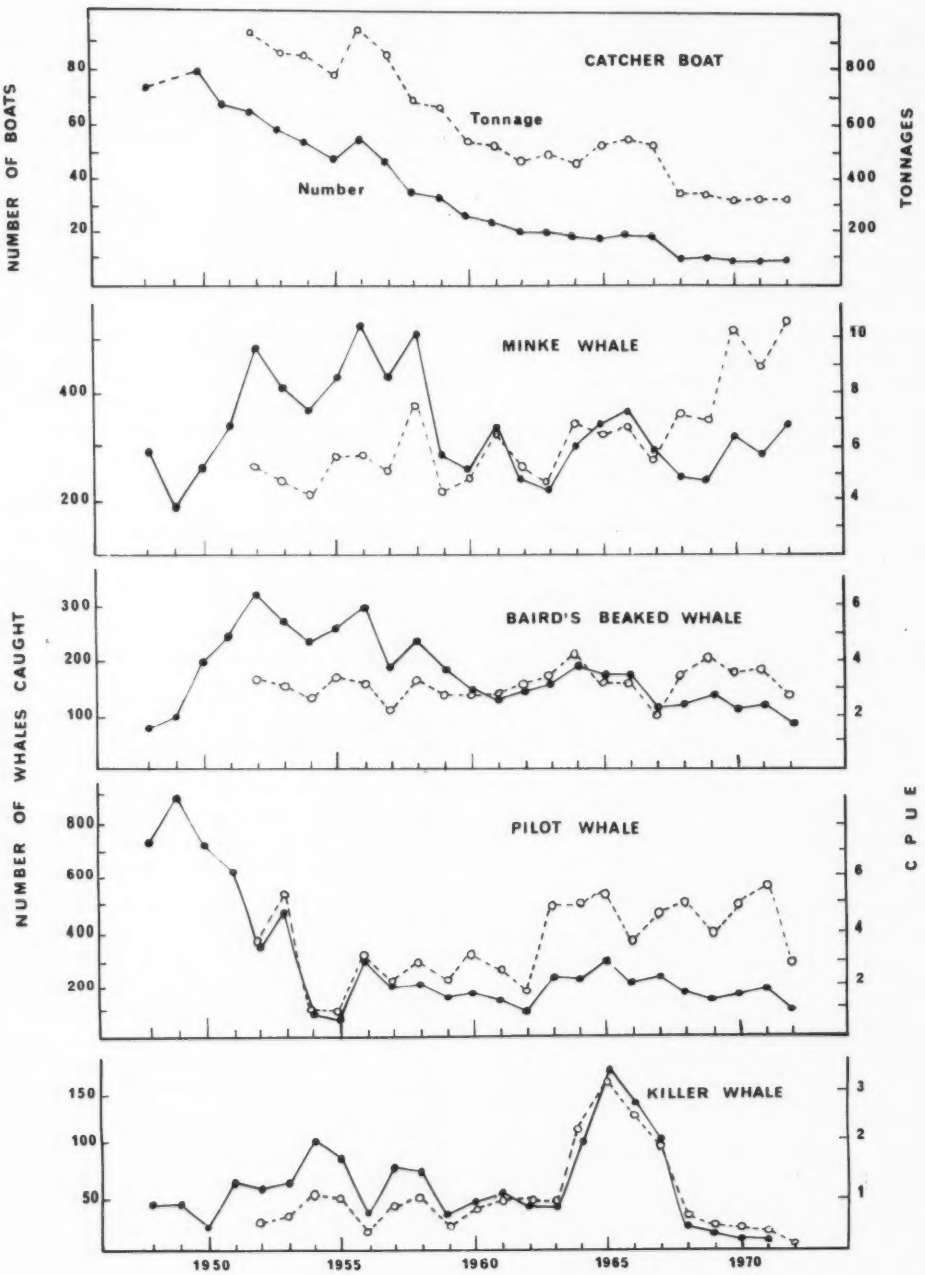


FIG. 2. Yearly change in number and tonnage of small-type whaling boats and amount of catch by whale species from 1948 to 1972. Closed circle and solid line, number of whales caught; open circle and broken line, CPUE.

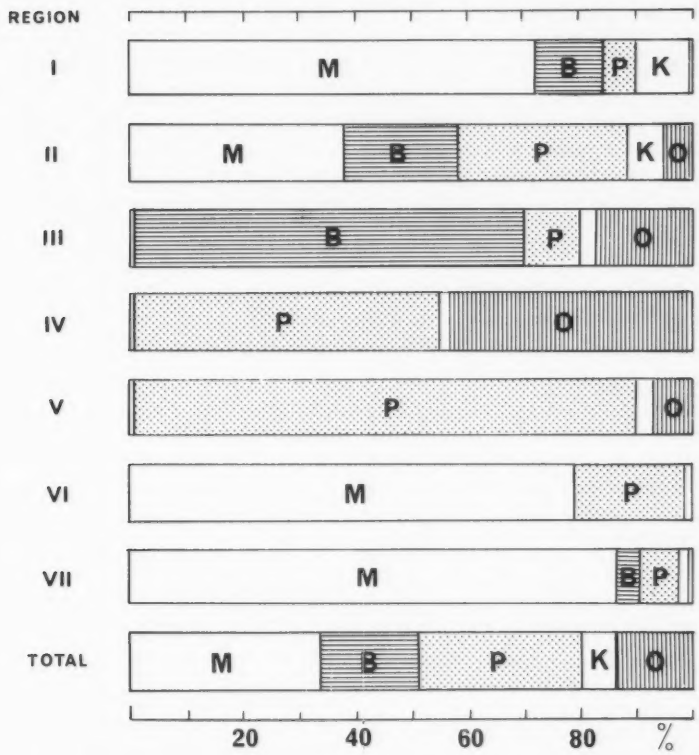


FIG. 3. Species composition of whales caught by small-type whaling in each region. M: minke, B: Baird's beaked, P: pilot, K: killer, O: others.

and Baird's beaked whales are not abundant, and the size of the catcher boats is less than 10 tons. The catch of minke, Baird's beaked, and killer whales is only 1.2, 0.1, and 1.8%, respectively, of the total catch in this region. Pilot whales are dominant (53.7%), and other species comprise the remainder of the catch. Many kinds of relatively rare cetacean species are caught in this region, but most of the "others" are dolphins. As many smaller cetaceans are caught, this region accounts for 23.3% of the total catches in Japan.

Region V — Since 1954, whaling has almost completely ceased in this region. Most of the catch was comprised of pilot whales (89.8%). There was no catch record of Baird's beaked whale. Minke, killer, and other whales comprise 0.9, 2.5, and 6.8% of the catch, respectively. The catch ratio is only 2.4% of the total catch in Japan.

Region VI — Small-type whaling in this region has continued at a low level, mainly taking minke whales. The catch ratio is only 2.9% of the total. Minke whales comprise 79.4% of the whales caught in this region. Pilot, killer, and other whales are 19.0, 1.5, and 0.2% of the catch, respectively. Baird's beaked whale has not been caught in this region.

Region VII — Small-type whaling started in this region in 1950, but it has not been very active since 1956. The catch ratio is only 1.6% of total catches in Japan. Most of the whales caught are minke whales (86.8%), and Baird's beaked, pilot, killer, and others comprise 3.8, 6.8, 2.2, and 0.5% of the catch, respectively.

Figure 4 shows the catch ratios of regions for each whale species. Difference in catch ratios are attributable to the difference in abundance of whales in each region.

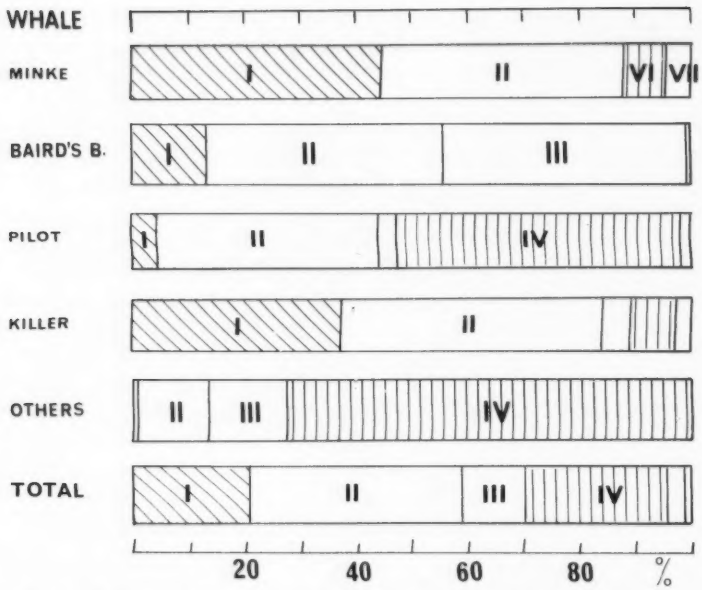


FIG. 4. Regional composition of whales caught by small-type whaling for each whale species. I: Hokkaido, II: Sanriku, III: Chiba, IV: Wakayama, V: Shikoku, VI: Kyushu, VII: Sea of Japan.

Minke whale — Most of the minke whales are caught in Regions I and II. They comprise 44.4 and 43.7% of the catch, respectively. Minke whales are caught in all regions, but the catch in Regions III, IV, and V is very small (0.4, 0.7, and 0.01%, respectively). Catches in Regions VI and VII are 6.8 and 4.1%, respectively. Minke whales occupy 33.4% of the total catch in Japan. Omura and Sakiura (1956) plotted catch positions of this species.

Baird's beaked whale — Almost all of these whales are caught in Regions I, II, and III (99.5%). The catch ratios in these regions are 13.6, 42.6, and 43.4%, respectively. There are no catch records in Regions V and VI, and catches are also rare in Regions IV and VII (0.1 and 0.3%, respectively). Omura et al. (1955) and Nishiwaki and Oguro (1971) plotted catch positions of this species around the Japanese coast. The catch of this species comprises 17.6% of the total catch.

Pilot whales — The catch is largest in Region IV (42.9%), and second largest in Region II (39.9%), though these whales are caught in all regions. Catch ratios in Regions I, III, V, VI, and VII are 4.0, 3.7, 0.7, 1.9, and 0.4%, respectively. There has been a long history of pilot whale catching in Regions IV and V, but the catch in Region V has been inactive since 1954.

Killer whale — Although this species is caught in all regions, most of them are caught in Regions I and II (36.9 and 47.6%, respectively). Catches in other regions are 5.6, 7.4, 1.1, 0.8, and 0.6% in Regions III, IV, V, VI, and VII, respectively. The catch of this species is low compared with other species (5.6%, and pilot whales comprise 29.2%). Nishiwaki and Handa (1958) plotted catch positions of this species during the years 1948–57.

Others — Most of the whales classified in this category are caught in Region IV (71.4%). In Regions II and III catches are 12.7 and 13.9%, respectively. Catches are rare in other regions (0.8, 1.1, 0.03, and 0.06% in Regions I, V, VI, and VII, respectively). The catch ratio of "others" comprises 14.2% of total catches.

WHALING SEASON

The whaling season for taking minke whales was limited to 6 mo, from February 1 to July 31 from 1952 until 1954, though there had been no

restriction in whaling season in the previous years. It was changed with an amendment of the schedule in the Annual Meeting of the International Whaling Commission in 1954, that the minke whaling season was to be limited in Hokkaido to 6 mo from April 15. It was limited in other areas to 6 mo from January 15 since 1955, because the migration of minke whales in Hokkaido is later than in other areas. There is no legal limit for a whaling season on the other species that are the objects of small-type whaling.

Figure 5 shows the percentage frequencies of whales caught from Japanese coastal waters by month during years 1954–71. The patterns are different between species.

Minke whale — The main whaling season for this species is from April to July, with a peak in May. Omura and Sakiura (1956) showed the difference in whaling seasons by regions.

Baird's beaked whale — The main whaling season is from June to November, with a peak in August. Omura et al. (1955) and Nishiwaki and Oguro (1971) examined the whaling season of this species, and showed the differences in whaling seasons by regions.

Pilot whales — There are two peaks in the whaling season in Japan; one is in June, and another is in October. Matsuura (1943b) reports that the catch of pilot whales in Wakayama, where *Globicephala macrorhynchus* is the main object, flourishes from April to June. On the contrary, the catch of pilot whales in Sanriku where *G. melaena* is the main object has a flourishing season from August to October. Pilot whales are caught in all months.

Killer whale — The catch of killer whales gradually increases from January, and there is a peak in November. Nishiwaki and Handa (1958) showed the differences in whaling seasons by regions.

Other cetaceans — As noted frequently, several cetacean species are included in this category, but dolphins are most numerous. These cetaceans are caught throughout the year, but there is a peak in January, and they are relatively scarce from June to October. This pattern is similar to the seasonal catch of dolphins caught by local fisheries around the Japanese coast (Ohsumi 1972). Omura et al. (1955) noted the monthly catch of goose-beaked whales. According to them, these whales are caught in all months of the year, but most of the catches are from May to October, with a peak in August.

Products and Utilization

The whales that are caught by small-type whaling are flensed and separated into blubber, meat, bones, and internal organs. Meat of all species and blubber of minke whales are used for human consumption. Whale oil is extracted from blubber, bones, and internal organs. Whale oil has a utilization similar to that of sperm whale oil. Some meat, internal organs, and residues in oil cookers are used for making meal and fertilizer.

Table 3 shows the amounts and prices produced by small-type whaling since 1961. Annual production has gradually been decreasing since 1965, accompanying the decline in catch. The total products are 1833.8 tons, the average of years 1961–72. Meat and blubber for human consumption comprise 59% of the total products, and average 1081.2 tons. Whale oil products average 401.0 tons annually and comprise 22% of the total products. Other products average 361.7 tons annually and make up 19% of the total products. The price of the products has been rather constant notwithstanding the decline in the amount of products, and averages 166 million yen per annum.

Ministerial Ordinance on the Small-Type Whaling

As mentioned above, small-type whaling had been freely licensed, except in Chiba prefecture, before the end of World War II. During and after the war, many operators began to join in this whaling. On December 5, 1947 the Japanese Government appointed this kind of fishery as a designated fishery, which needed permission for operation by the Minister of Agriculture and Forestry. The ministerial ordinance for small-type whaling is similar to that for large-type whaling based from land stations. Since 1951, when Japan joined the International Convention for the Regulation of Whaling, some regulatory items have been added or amended in the ordinance.

The main articles of the present ministerial ordinance on small-type whaling are as follows:

1, Limit in number of catcher boats: Ten catcher boats have been permitted since 1968.

2, Limit of whaling gun: Whaling gun is limited to within 50-mm caliber.

3, Limit of use of land station: When a land station is built, or whalers use a land station, whalers need the permission of the government.

4, Limit of whale species: Catch of baleen whales (except the minke whale) and the sperm whale, is forbidden.

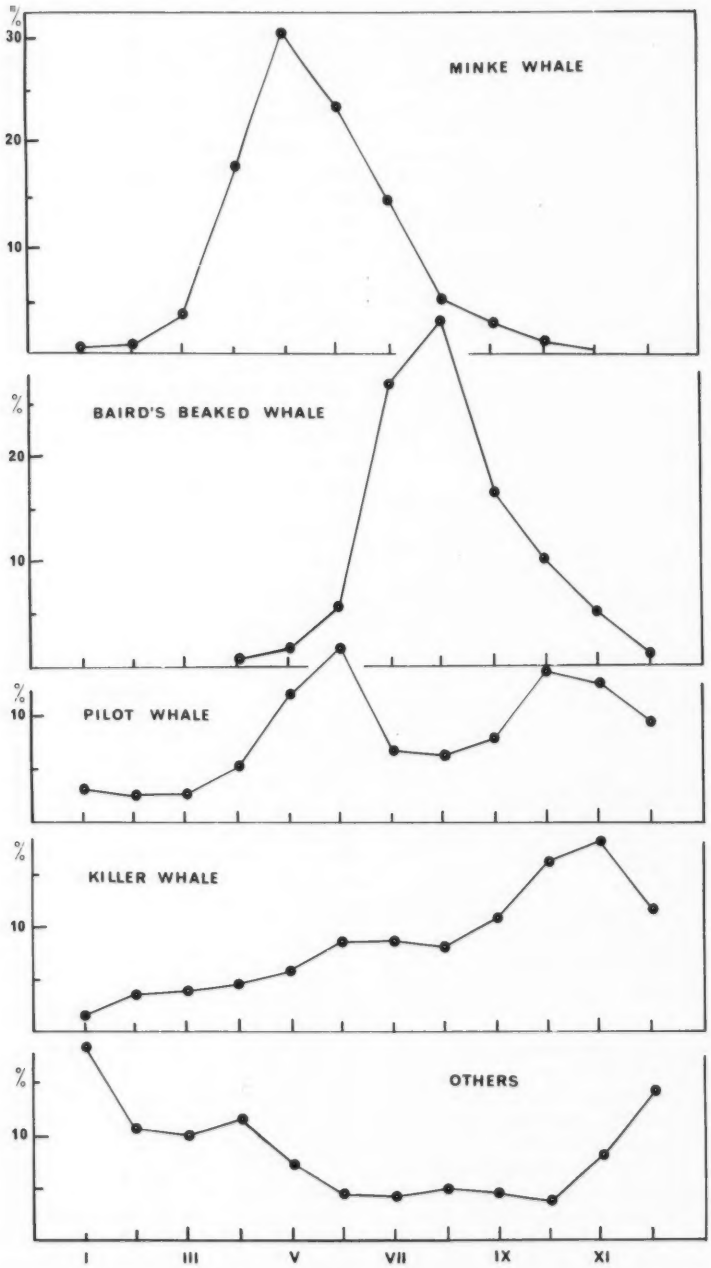


FIG. 5. Monthly catches of whales by small-type whaling in the waters adjacent to Japan (1954–71).

TABLE 3. Amounts of products by small-type whaling in Japan.

Year	Oil (*ton*)	Food (*ton*)	Others (*ton*)	Total (*ton*)	Price (*million yen*)
1961	364	1242	452	2058	110
1962	362	1058	377	1797	110
1963	492	1064	380	1936	140
1964	626	1411	495	2532	140
1965	575	1581	471	2626	200
1966	471	1263	491	2225	200
1967	390	1832	412	1832	170
1968	368	1529	280	1529	130
1969	393	873	324	1590	160
1970	287	950	219	1456	200
1971	280	843	211	1334	220
1972	203	779	108	1090	210

5, Limit of catch: Killing a calf, and cow with calf is prohibited.

6, Limit of whaling season: The following whaling seasons are set for the minke whale: Hokkaido, April 15–October 14; Other areas, January 15–July 14. Other whale species are not limited to a season.

7, Towing a carcass caught by another catcher boat is banned.

8, All whales caught must be completely utilized.

9, Monthly and annual reports on operations must be submitted to the government: a) Monthly catch report: Date and position of whales caught, name of catcher boat, name of gunner, whale species, sex, body length, food, fetus, and other remarks on each whale caught; b) Annual report on result of operations: Outline of operation, boats used, whaling season, amounts of catch and products, payment to crew, income and expenditures, etc.

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Progress Report on Small Cetacean Research in Chile[1]

ANELIO AGUAYO L.

Casilla 291 Concón, Chile[2]

AGUAYO L., A. 1975. Progress report on small cetacean research in Chile. J. Fish. Res. Board Can. 32: 1123–1143.

The geographic distribution is plotted, and where known, the seasonal occurrence with new data on sightings is given for the smaller Cetacea of Chile. Species documented are: *Cephalorhynchus commersonii, C. eutropia, Delphinus delphis, Lissodelphis peronii, Lagenorhynchus australis, L. obscurus, L. cruciger, Tursiops* sp., *Grampus griseus, Orcinus orca, Globicephala melaena*, and *Phocoena spinipinnis*. Several small dolphin fisheries exist. The pilot whale may be exploited in the future in Chile.

AGUAYO L., A. 1975. Progress report on small cetacean research in Chile. J. Fish. Res. Board Can. 32: 1123–1143.

L'auteur indique la répartition géographique et, lorsque connue, l'occurrence saisonnière, fondée sur des signalements nouveaux, des petits cétacés du Chili. Les espèces traitées sont: *Cephalorhynchus commersonii, C. eutropia, Delphinus delphis, Lissodelphis peronii, Lagenorhynchus australis, L. obscurus, L. cruciger, Tursiops sp., Grampus griseus, Orcinus orca, Globicephala melaena et Phocoena spinipinnis*. Il y a plusieurs pêcheries de petits marsouins. Il est possible que le globicéphale noir soit exploité à l'avenir au Chili.

Accepted March 14, 1975 Accepté le 14 mars 1975

WHALE research in Chile is conducted jointly by the University of Chile and the Ministry of Agriculture, and whaling is regulated by the Permanent Commission for the Exploitation and Conservation of the South Pacific Marine Resources (Aguayo 1974).

In the past few years, reference to the biology of dolphins and porpoises has been made for the Chilean area by Fraser (1937, 1955), Oliver (1946), Yañez (1948), Olrog (1950), Mann (1958), Cabrera (1961), Clarke (1962), Aguayo (1966), Aguayo and Torres (1967), Norris (1968), Markham (1970), Gilmore (1971), and Brown (1973).

Clarke (1962) pointed out that the taxonomy and bionomics of the dolphins of the west coast of South America represent a considerable field for research, virtually untouched since the pioneering work of Philippi in 1893 and 1896. In this region, moreover, dolphins and blackfish may be a potential food resource for the domestic market.

Modern dolphin research began in Chile in 1968 with the arrival at Montemar (Department of Oceanology, University of Chile) of Dr K. S. Norris from the University of California under the aegis of the agreement between both universities. Dr. Norris and I are now attempting to produce a comprehensive study of the porpoise and small whale fauna of Chile. The work includes a review of the systematics of these animals, their distribution, variation, and natural history.

To date there has not been whaling on the smaller cetaceans in Chile, in spite of their relative abundance. From time to time the fishermen sell some dolphin meat in the local market in Arica, Iquique, Antofagasta, and Coquimbo (from 18°20′S to 30°S), and in the south around Concepción and Valdivia (37°S to 40°S), but in general Chilean people know very little about dolphin products (Aguayo 1975). Thus, this contribution has been prepared to give some of the information we have gathered on smaller cetaceans of the families Delphinidae and Phocoenidae in Chile.

Family Delphinidae

Eight genera have been recorded in Chilean waters: *Cephalorhynchus, Delphinus, Lissodelphis, Lagenorhynchus, Tursiops, Grampus, Orcinus* and *Globicephala*. *Pseudorca* and *Stenella* are also mentioned by some authors but at present I do

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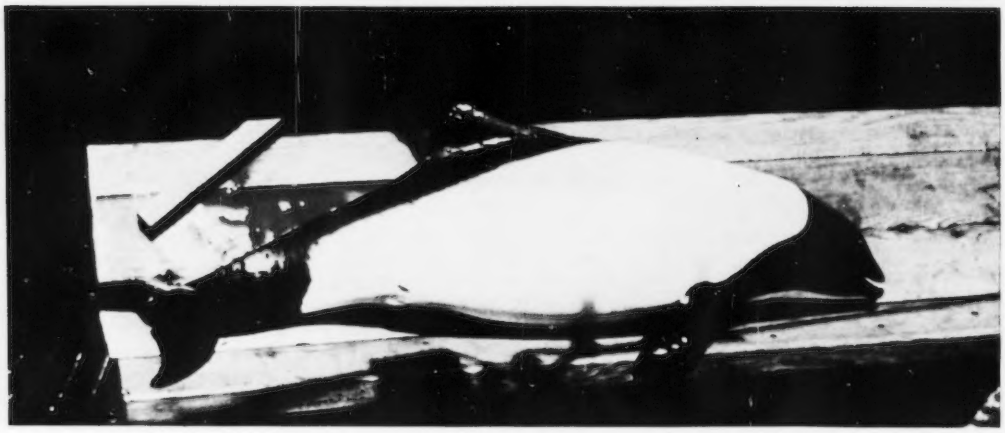

FIG. 1. *Cephalorhynchus commersonii* on board R/V *Hero*, Strait of Magellan, December 1968 (photo A. Aguayo).

not know if these two genera can be cited for the area or not.

Cephalorhynchus commersonii (Lacépède, 1804)
COMMERSON'S DOLPHIN. TUNINA OVERA OR DELFÍN DE MAGALLANES.

This coastal and pelagic species was cited for the area by Fraser (1937), Yañez (1948), Olrog (1950), Mann (1958), Cabrera (1961), Aguayo and Torres (1967), Norris (1968), and Gilmore (1971). Fraser (1937) pointed out that the range of distribution of this species is in the region at the southern end of South America. It has been observed in the Straits of Magellan, near Tierra del Fuego and at the Falkland Islands. Olrog (1950) observed it twice in the Beagle Channel in December 1948.

Aguayo and Torres (1967) reported sighting this porpoise on three occasions in the Drake Passage during the track of the Twentieth Chilean Antarctic Commission Cruise:

	(1 porpoise)	
Feb. 27, 1966	1738 h	61°59′S, 63°05′W
	(12 porpoises)	
Feb. 27, 1966	1900 h	61°50′S, 63°17′W
	(5 porpoises)	
Feb. 28, 1966	1730 h	58°10′S, 67°58′W

Norris (1968) observed this animal on 10 occasions and also captured two specimens in the Straits of Magellan on December 10, 1968. The largest school seen contained 10 individuals. Gilmore (1971) observed this porpoise in the central Strait of Magellan in May 1970.

Aguayo and Maturana (unpublished data) observed this porpoise 4 times during the track of the Twenty-Seventh Chilean Antarctic Commission Cruise:

	(2 porpoises)	
Dec. 4, 1972	2130 h	South of Navarino Is.
	(3 porpoises)	
Dec. 5, 1972	1900 h	Drake Passage
	(2 animals)	
Feb. 20, 1973	1038 h	North of Wollaston Is.
	(4 animals)	
Feb. 21, 1973	0830 h	Strait of Magellan

The color of this beautiful porpoise is exactly as Fraser (1937) described it (see Fig. 1 and 2).

To date, the distribution of this animal can be summarized as follows: Atlantic and Pacific coasts of the southern end of South America, Straits of Magellan, Falkland Islands, Drake Passage, and, according to Angot (1954), Kerguelen Island in the southern Indian Ocean. The known distribution of this species in Chilean waters is shown in Fig. 3.

FIG. 2. *Cephalorhynchus commersonii* swimming in the Drake Passage, February 1966 (photo A. Aguayo).

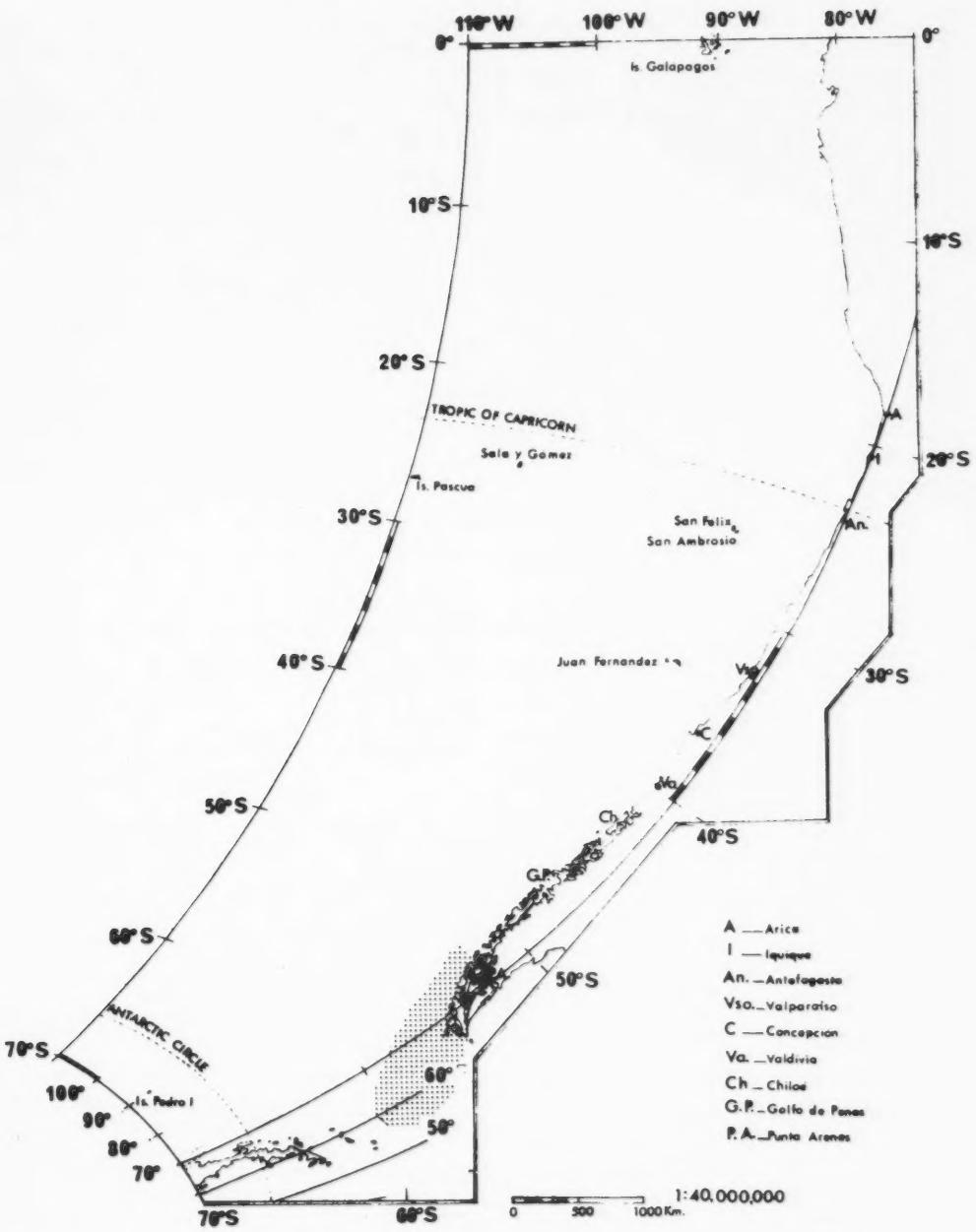

FIG. 3. Actual distribution of *Cephalorhynchus commersonii* in Chilean waters.

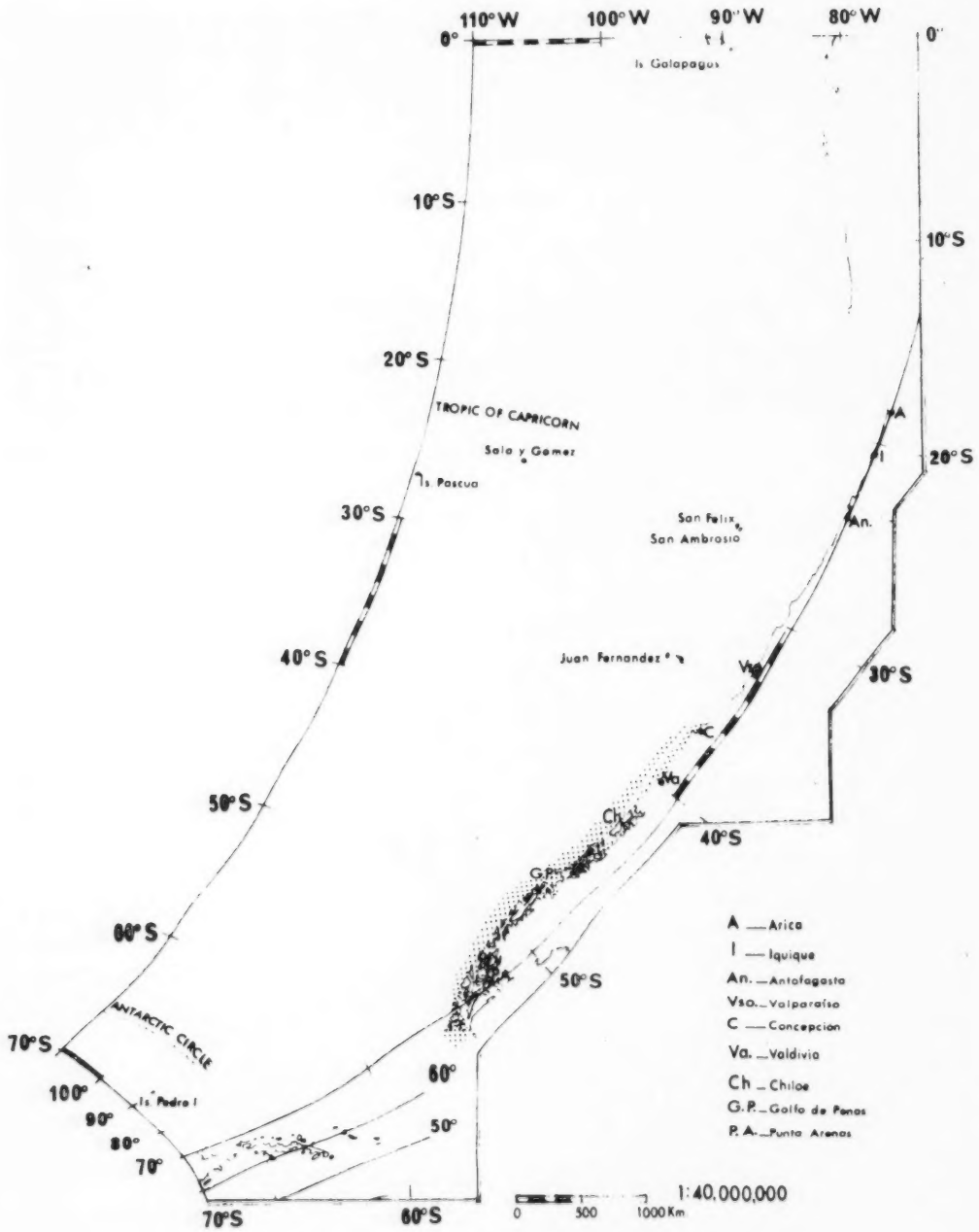

FIG. 4. Actual distribution of *Cephalorhynchus eutropia* in Chilean waters.

TABLE 1. Dolphins observed off the coast of Chile in 1966.

Date	Region	*Lissodelphis*	*Delphinus*	*Globicephala*
Mar. 25–Apr. 3, 9 days	33°S–46°S 72°W–78°W	558–668	52	102–114
Oct. 9–20, 11 days	32°S–44°S 72°W–78°W	44–56	10–12	91–96
Dec. 13–23, 10 days	33°S–49°S 72°W–78°W	286–331	–	25–35

Cephalorhynchus eutropia (Gray, 1849).
BLACK OR CHILEAN DOLPHIN. TUNINA NEGRA OR DELFÍN CHILENO.

This coastal species was cited for the area by Fraser (1937), Oliver (1946), Yañez (1948), Mann (1958), Cabrera (1961), and Norris (1968). Fraser (1937) pointed out that this dolphin is a rare South American species. Most of the body is darkly pigmented, but there are patches of white on the throat, behind the flippers, and on the belly. Yañez (1948) and Cabrera (1961) reported that it is known only from the Chilean coast of the southeast Pacific.

Norris (1968) stated that two specimens of this little known porpoise were obtained, and perhaps 100 were seen and studied at sea between Concepción and Valdivia (37°S–40°S). The first existing measurements and photographs of this animal were also taken in the fjord region of Chile, where Dr Norris identified this porpoise on five more occasions:

(1 porpoise)
Nov. 16, 1968 1440 h 41°45′S, 73°50′W
(5 porpoises)
Nov. 18, 1968 1400 h 43°04′S, 73°31′W
(3 porpoises)
Dec. 1, 1968 1000 h 55°02′S, 68°09′W
(Following 8–14 porpoises)
Dec. 6, 1968 1445–1540 h 55°14′S, 67°48′W
(Following 2 porpoises)
Dec. 7, 1968 1700–1800 h 55°02′S, 68°09′W

This porpoise was very shy and refused to allow close approach (Norris 1968).

Daniel Torres (personal communication 1974) found in Queule, a little north of Valdivia, Chile, October 1972, that the fishermen used this animal and also other species of dolphins as bait and human food.

Since this species is found only along the southern coast of Chile (from 37°S to 55°S) I suggest the common name "Chilean dolphin" to denote this species in the future. The known distribution of this species in Chilean waters is shown in Fig. 4.

Delphinus delphis Linné, 1758.
COMMON DOLPHIN. DELFÍN COMMÚN.

This pelagic and coastal species was cited for the area by Oliver (1946), Yañez (1948), Mann (1958), Cabrera (1961), Clarke (1962) and Aguayo (1966). Oliver (1946) stated that this species appears in the province of Concepción, Chile, at the end of autumn. Cabrera (1961) pointed out that it is found in all seas between 60°N and 45°S, and is very common on South American coasts. Clarke (1962) observed this dolphin intermingled with *Globicephala* at 30°28′S, 73°05′W. He also cited this dolphin for Ecuador. Bini (1951) also cited this species for Perú in waters near Paita.

Aguayo (1966) recorded this animal on three occasions (see Table 1):

(50 dolphins)
Mar. 25, 1966 1500 h 33°15′S, 72°09′W
(2 dolphins)
Mar. 27, 1966 1200 h 40°47′S, 74°55′W
(10–12 dolphins)
Oct. 19, 1966 1100 h 35°50′S, 73°50′W

The triple coloration and the long beak of this animal are characteristic. The known distribution of this species in Chilean waters is shown in Fig. 5.

Lissodelphis peronii (Lacépède, 1804)
SOUTHERN RIGHT-WHALE DOLPHIN. TUNINA SIN ALETA OR DELFÍN LISO.

This pelagic and coastal species was cited for the area by Oliver (1946), Yañez (1948), Fraser (1955), Mann (1958), Cabrera (1961), Aguayo (1966), Gilmore (1971), and Brown (1973).

Oliver (1946) stated that this dolphin is a common species in the littoral of the province of Concepción. Yañez (1948) noted that its distribution is in the southern Pacific and on the coast of Chile to Cape Horn.

Fraser (1955), referring to the distribution of this species, said, "The well-substantiated places of occurrence of *Lissodelphis peroni* indicate that it probably ranges round the world in the

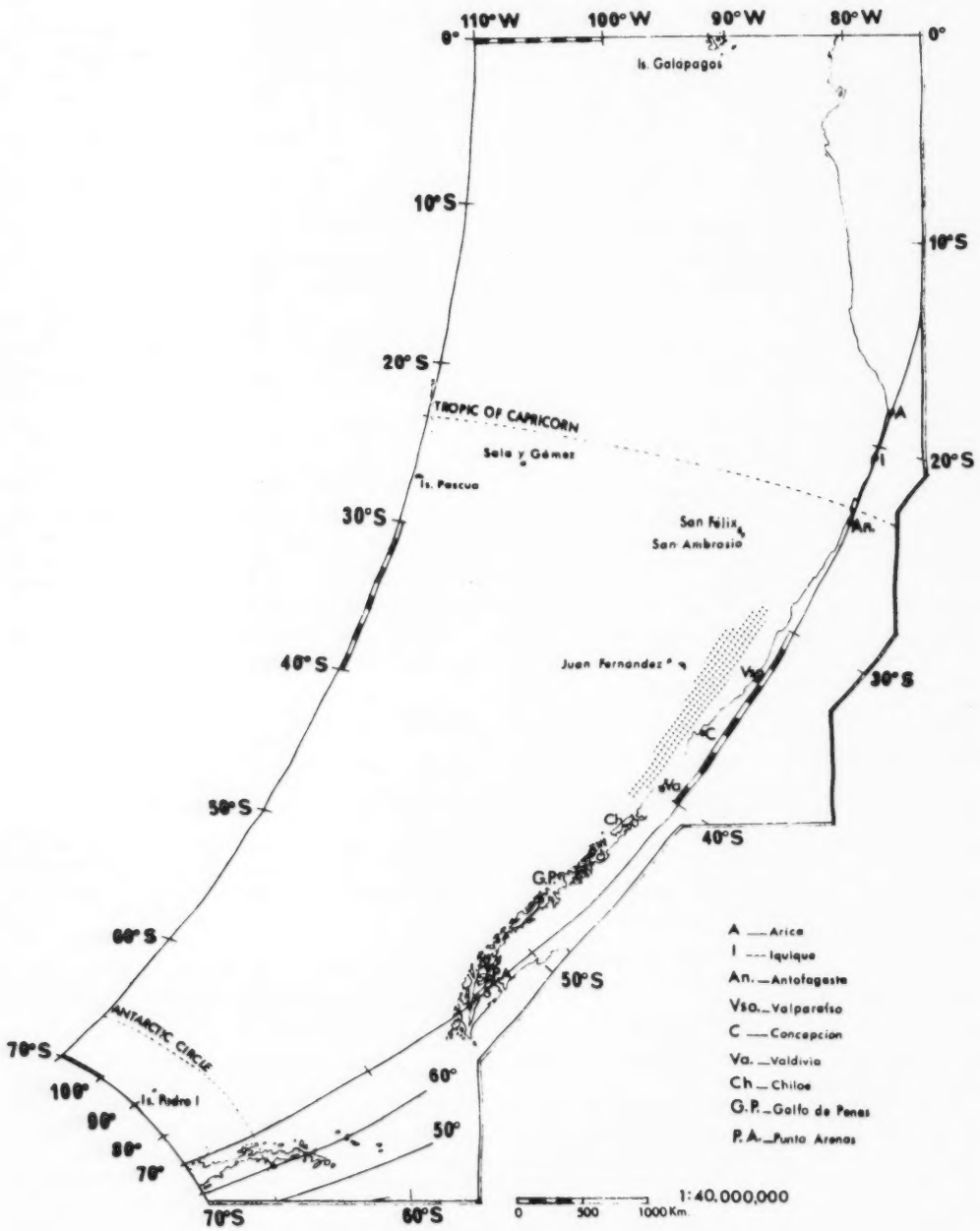

FIG. 5. Actual distribution of *Delphinus delphis* in Chilean waters.

FIG. 6. Lateral view of a live female *Lissodelphis peronii*, Concón, February 1968 (photo A. Aguayo).

FIG. 7. Ventral view of the same animal (photo A. Aguayo).

southern hemisphere. Although it is not entirely restricted to the West Wind Drift it appears to have some predilection for it, because ... those records to the north of the Sub-tropical Convergence are for the most part close to that boundary, and except for one sight record there is no evidence that it penetrates into the Antarctic Ocean." Fraser (1955) also published the first photographic record of this species, thanks to Mrs G. J. Goulter of New Zealand.

Aguayo (1966) stated that during the three cruises organized to observe cetaceans, about 1000 animals were sighted between 33°S and 49°S (Table 1). The two largest schools sighted were:

		(about 500–600 dolphins)
Apr.	3, 1966	33°41′S, 73°13′W
		(about 200 dolphins)
Dec.	21, 1966	45°14′S, 77°37′W

On February 12, 1968, I made another observation of this dolphin: the fishermen of Caleta Higuerillas, Concón, caught one female *Lissodelphis* with a hook half a mile off the coast (Fig. 6–9). I was informed and I bought the animal still alive. I was surprised because the hook was not in the interior of the mouth; it had been caught in one flank of the body. After we took out the hook, we put penicillin in the wounds, brought the dolphin onboard a small boat, and released it about 2 miles away. The dolphin made two circles around the boat and then went directly to the open ocean.

The color of this dolphin was exactly as Fraser (1955) described it, but the pectoral fins showed a grey pigmentation, more developed on the right flipper; the body of the dolphin was slender and the tip of the lower jaw protruded a very short distance beyond the upper.

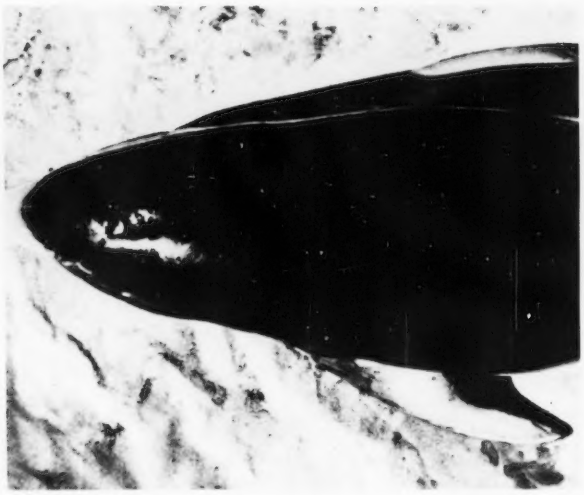

FIG. 8. Dorsal view of the cephalic region of the same animal (photo A. Aguayo).

FIG. 9. Dorsal view of the caudal region of the same animal (photo A. Aguayo).

Gilmore (1971) reported this dolphin from near Golfo de Arauco in June 1970. Brown (1973, Table 1) gave two records for the area:

(20 dolphins northwest of Coquimbo)
Jan. 31, 1970 29°35′S, 71°45′W
(50 dolphins between Arica and Iquique)
Sept. 17, 1970 18°53′S, 71°43′W

Dr Brown also commented on the pattern of distribution of this dolphin, the numbers in schools, its behavior, and a possible aberrantly colored individual.

Summarizing, we conclude that the known distribution of this species in Chilean waters ranges from the neighborhood of Cape Horn to Arica (Fig. 10).

Lagenorhynchus australis (Peale, 1848)
PEALE'S PORPOISE. DELFÍN AUSTRAL OR LLAMPA.

This coastal species was cited for the area by Fraser (1937), Mann (1958), Cabrera (1961), Norris (1968), and Gilmore (1971). Fraser (1937) reported that it is found in the neighborhood of Cape Horn, Chile, Patagonia, and the Falkland Islands.

Norris (1968) observed this porpoise between the Golfo de Arauco and Cape Horn (Fig. 11 and 12). The best existing series of this animal was obtained here, including complete skeletal, morphological, anatomical, and parasitological specimens. This included nine animals gathered over about 200 miles of the shoreline. Pulsed sounds also were recorded and analyzed from this species by Schevill and Watkins (1971).

Gilmore (1971) observed this porpoise in the central Strait of Magellan (see Fig. 13).

Aguayo and Maturana (unpublished) observed this porpoise on six occasions during the track of the Twenty-Seventh Chilean Antarctic Commission Cruise:

(3 animals)
Dec. 4, 1972 0630 h Beagle Channel
(2 animals)
Dec. 4, 1972 0830 h Beagle Channel
(8 animals)

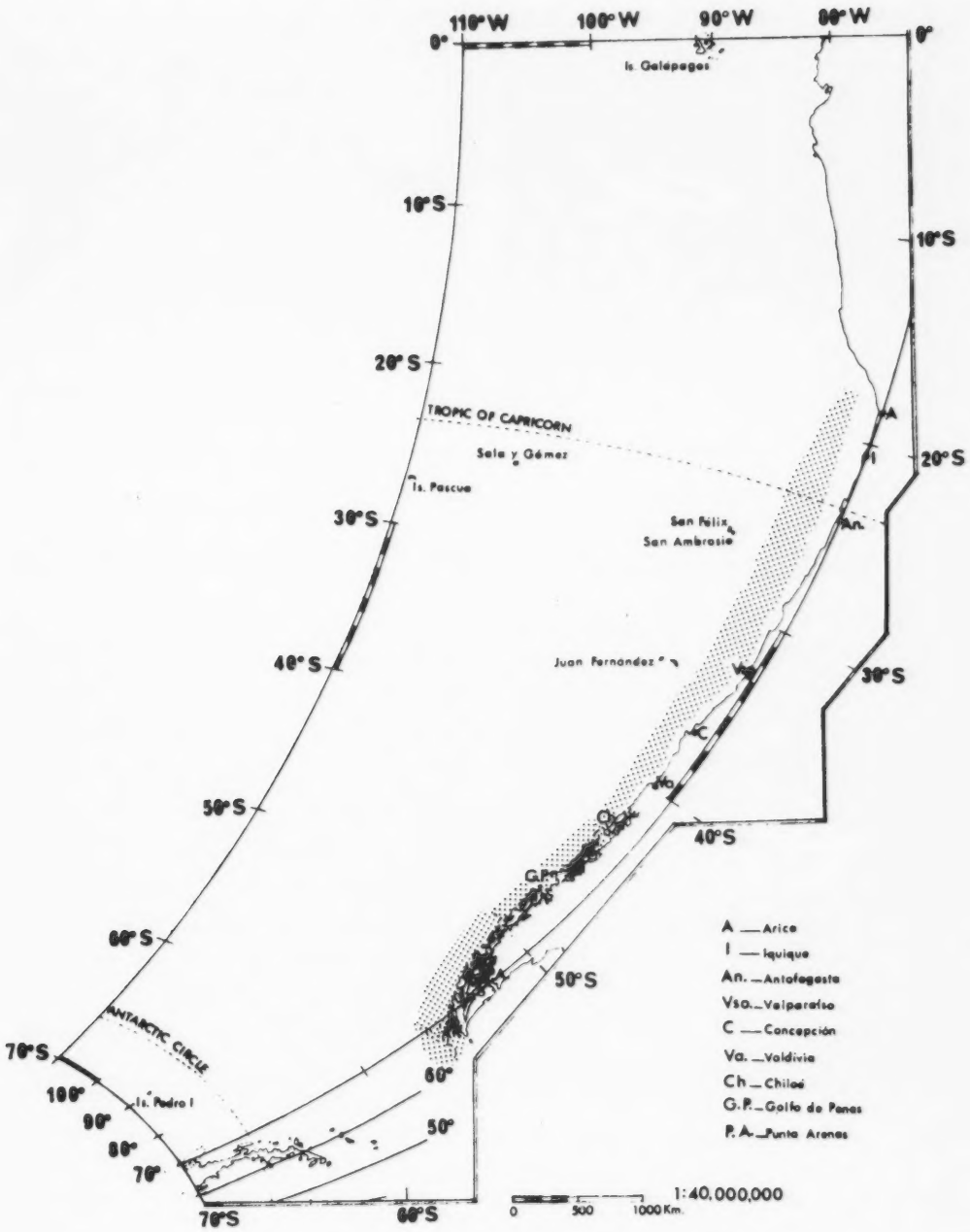

FIG. 10. Actual distribution of *Lissodelphis peronii* in Chilean waters.

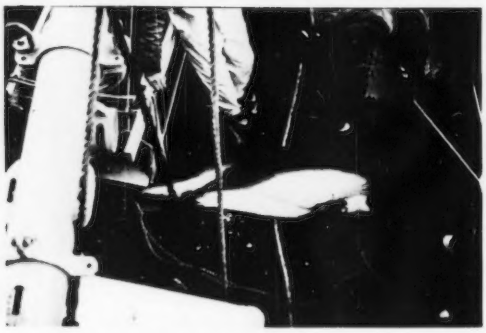

FIG. 11. Lateral view of *Lagenorhynchus australis* on board R/V *Hero*, south of Chiloe Island, December 1968 (photo A. Aguayo).

Dec. 4, 1972 1230 h Beagle Channel
(2 animals)
Dec. 4, 1972 1500 h Beagle Channel
(4 animals)
Dec. 4, 1972 1800 h Murray Channel
(4 animals)
Dec. 4, 1972 2030 h South of Navarino Is.

Aguayo (unpublished) observed it on 10 occasions during the cruise of R/V *Calypso* between Punta Arenas and Puerto Montt, Chile, March 15–April 3, 1973:

(2 animals)
Mar. 16, 1973 0830 h Strait of Magellan
(1 animal)
Mar. 16, 1973 0920 h 52°56′S, 73°35′W
(2 animals)
Mar. 16, 1973 1700 h Providencia Island
(2 animals)
Mar. 16, 1973 1820 h 52°56′S, 73°45′W
(3 animals)
Mar. 16, 1973 1840 h Tamar Island
(4 animals)
Mar. 16, 1973 1900 h Tamar Island
(2 animals)
Mar. 18, 1973 0830 h 50°44′S, 74°45′W
(1 animal)
Mar. 20, 1973 1750 h 50°27′S, 75°11′W
(5 animals)
Apr. 2, 1973 0900 h 45°47′S, 74°23′W
(4 animals)
Apr. 2, 1973 1840 h 45°13′S, 73°38′W

On January 2, 1970, I observed a school of four *L. australis* playing on the waves at the mouth of the Aconcagua River, Concón, between 1145 and 1200 h. Two days later, January 4, I observed a school of four *Grampus griseus* playing with another *L. australis* near Montemar, about 3 miles from the beach.

The known distribution of this species in Chilean waters is shown in Fig. 14.

Two other species of the genus *Lagenorhynchus*, *L. cruciger*, and *L. obscurus*, have been previously cited for the area, but at present I have not been able to sight and identify them. Fraser and Noble (1968) identified as *L. cruciger* a skull found by F. O'Gorman at Livingston Island, South Shetland Islands, and R. L. Brownell (personal communication 1974) observed *L. obscurus* in the Messier Channel (48°30′S, 74°33′W) while aboard the R/V *Hero* on August 15, 1969. It is possible that *L. australis* and *L. obscurus* may occur together in coastal central–southern waters of Chile. On the other hand, Norris (1968) found *L. obscurus* in Peruvian waters, so it is possible that *L. obscurus* may occur in more temperate waters than *L. australis*.

Bini (1951) also cited *L. fitzroyi* for Peruvian waters. His fig. 13 (1951, p. 91) shows the head of an *L. obscurus*, the right name for Fitzroy's dolphin, dusky dolphin, or southern striped dolphin.

Tursiops sp.

SOUTHERN BOTTLENOSED DOLPHIN. TUNINA DE LAS ISLAS OR TURSIÓN.

This pelagic and coastal animal was cited for the area by Oliver (1946), Rice and Scheffer (1968) and Gilmore (1971). Oliver (1946) stated that this dolphin appears occasionally in the waters of the Golfo de Arauco, Chile. Gilmore (1971) observed this dolphin at a half-day's run south of Isla San Ambrosio, also at Isla San Ambrosio, and again, a day's run west of Valparaiso. In the oceanic locality, a half-day's run south of Isla San Ambrosio, *Globicephala* and *Tursiops* (the latter in large numbers) were intermingled in the same area.

I have extracted from my diary these notes on *Tursiops* observations with Dr Gilmore:

> "June 25. 1000 hrs. 28°00′S, 77°55′W. At 1030 hrs we observed about 200 dolphins (probably *Tursiops*) with a school of 40 blackfish. These dolphins had a prominent dorsal fin [Fig. 15]. June 26. At 0430 hrs., we anchored near San Ambrosio Island and San Felix. Between 0900 and 1100 hrs., we rounded San Ambrosio Island and counted about 50 *Tursiops* sp., which accompanied our boat 20 minutes. These dolphins had a moderate beak, and the longest animal was about 4 meters long [Fig. 16]. The color of the dolphins was dark-grey on the dorsal surface and white-grey on the belly. Between 1350 and 1600 hrs., we rounded San Felix Island and at 1550 hrs., we observed another school of six *Tursiops* sp. for four minutes."

Clarke and Aguayo (unpublished) observed a

FIG. 12. Ventral view of the same animal (photo A. Aguayo).

FIG. 13. *Lagenorhynchus australis* jumping in the Strait of Magellan, October 1969 (photo T. Antezana).

school of 8–10 *Tursiops* at 34°04′S, 75°04′W, on November 25, 1964 (1850 h), and again 3 days later at 0720 hrs. they saw a school of eight animals associated with 30–40 blackfish at 31°18′S, 73°31′W. These dolphins played at the bow of the ship and were about 7 ft (2.1 m) long. The color was a uniform grey above (with long, narrow light streaks) and whitish below, but on that occasion we were not able to identify them (Fig. 17).

I also observed this dolphin at Juan Fernández on March 9, 1969, while I was censusing the Juan Fernández fur seal (*A. philippii*). I sighted a school of five animals between Más a Tierra and Santa

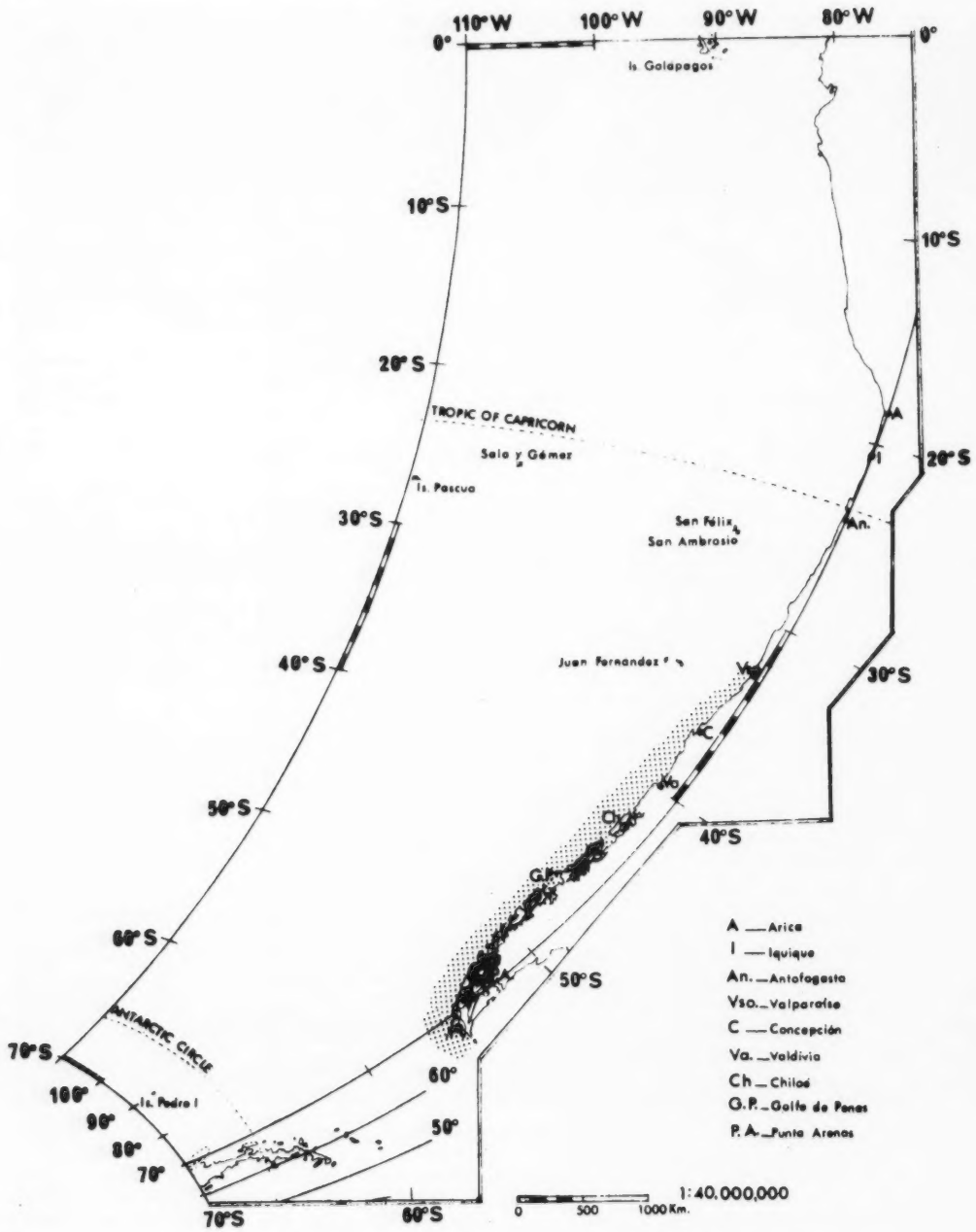

FIG. 14. Actual distribution of *Lagenorhynchus australis* in Chilean waters.

FIG. 15. Anterior view of the dorsal fin of a *Tursiops* sp., at sea near San Ambrosio Island, June 1970 (photo by A. Aguayo).

FIG. 16. Lateral view of the same animal (photo by A. Aguayo).

FIG. 17. Part of a school of 8–10 *Tursiops* sp., swimming under the bow of the whale-catcher *Indus* XIV, in 34°04′S, 75°04′W, November 1964 (photo by A. Aguayo).

Clara Islands at midday, but on that occasion I was not able to identify them.

Lévêque (1963) stated that *Tursiops* sp. is very abundant in the waters of the Galápagos Archipelago where it is possible to find it all the year round. Grimwood (1969) noted that *Tursiops truncatus aduncus* appears to be common in Peruvian coastal waters, from Mancora (03°45′S) to the Chilean border. It is sometimes caught by small boat fishermen, but captures are thought to be mainly accidental.

The known distribution of this dolphin in Chilean waters is shown in Fig. 18.

Grampus griseus (Cuvier, 1812).

RISSO'S DOLPHIN. FALSO CALDERÓN OR DELFÍN GRIS.

This pelagic and coastal species was cited for the area only by Mann (1958) and Norris (1968). Mann (1958) cited it as *Gramphidelphis griseus* but he did not indicate data or references of its distribution. Norris (1968) observed a school off Valparaiso and photographed it.

I observed this dolphin only on one occasion, 3 miles off Montemar (Valparaiso Bay). A school of four animals was playing with another smaller dolphin (*L. australis*) on January 4, 1970. The largest animal I saw was about 3.6 m long with the entire head whitish, dorsal fin falcate, and dark-grey flippers more or less pointed.

The known distribution of this species in Chilean waters is shown in Fig. 19.

Orcinus orca (Linné, 1758).

KILLER WHALE. ORCA OR BALLENA ASESINA.

This pelagic and coastal species was cited for the area by Oliver (1946), Yañez (1948), Olrog (1950), Mann (1958), Cabrera (1961), and Markham (1970). Oliver (1946) said that this animal had been taken several times by the whalers of Concepción. Yañez (1948) stated that it was found in southern Chilean waters and in the Antarctic. Olrog (1950) observed two killer whales off the coast of Grevy Island, south of the Bay of Nassau, on January 5, 1949. Markham (1970) observed a school of about six killer whales in Condor Fjord (53°23′S, 72°35′W) just a little north of the Strait of Magellan.

I have observed this dolphin on five occasions, and four of them were in the Antarctic: Apr. 8, 1964 — Near the whaling station, Chome, Talcahuano. A single animal (male) marauding the whale carcasses. Dec. 9, 1972 — Bransfield Strait. A school of 10 animals. Jan. 11, 1973 — Near Paraíso Bay (64°53′S, 62°53′W). Two schools

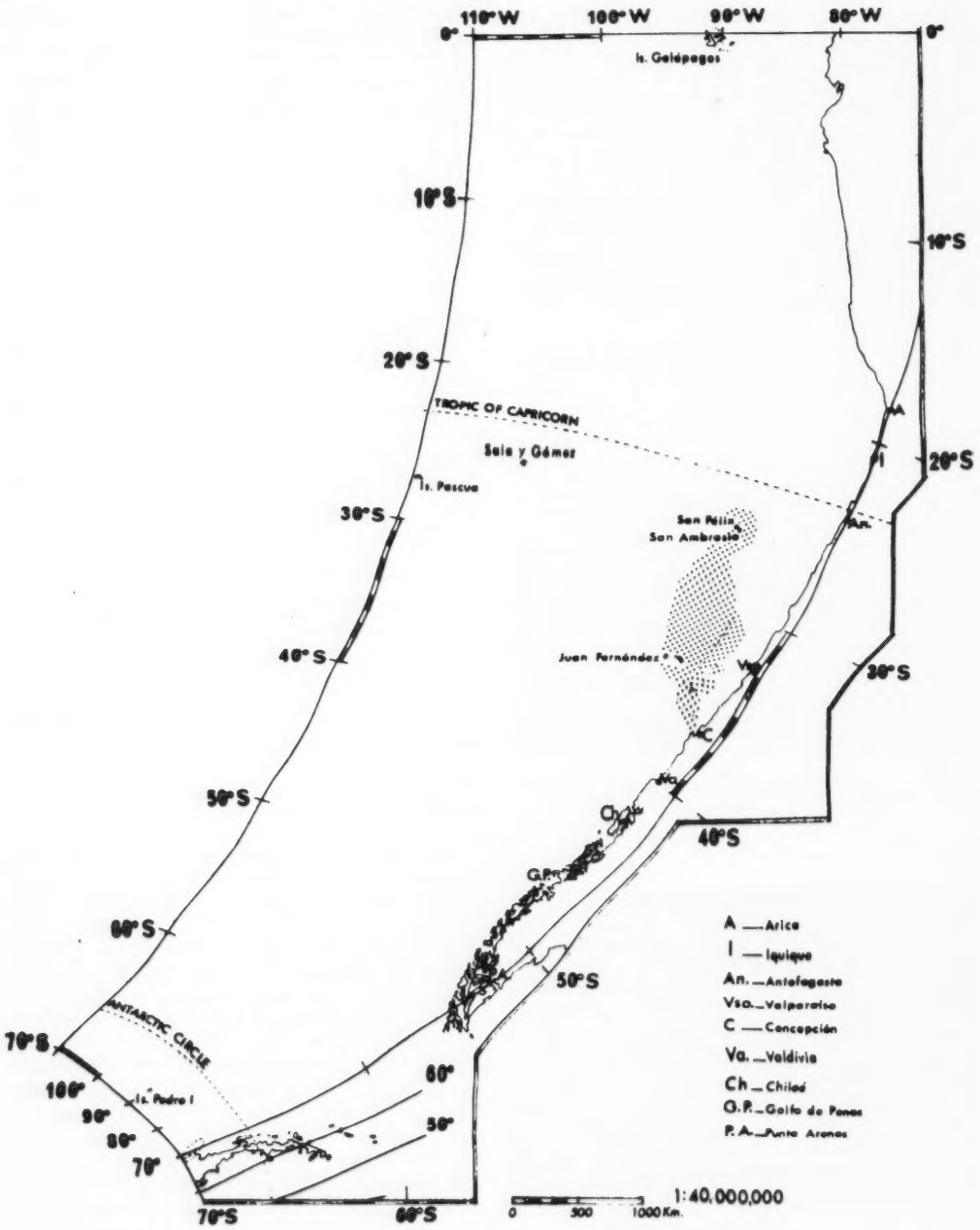

FIG. 18. Actual distribution of *Tursiops* sp., in Chilean waters.

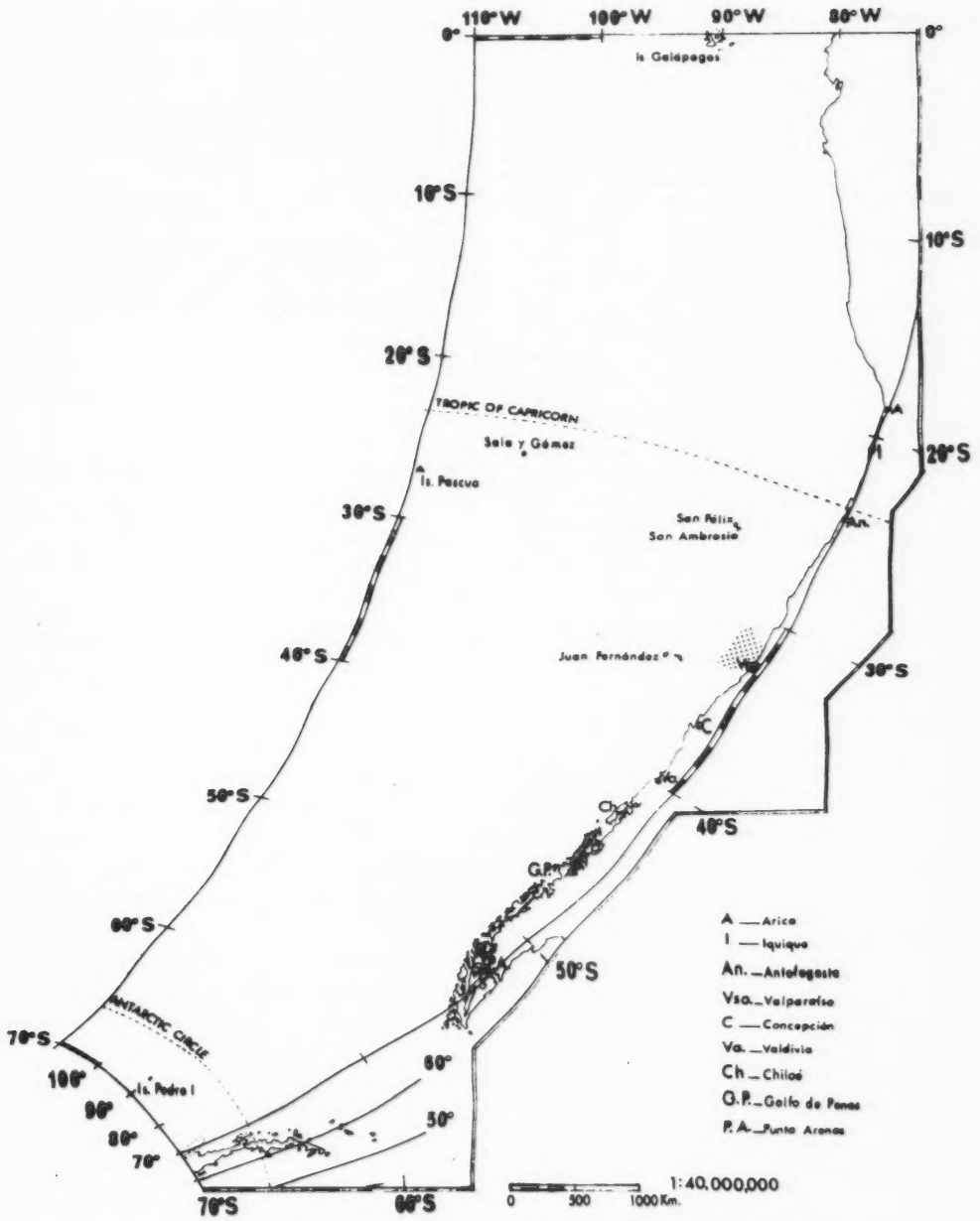

FIG. 19. Actual distribution of *Grampus griseus* in Chilean waters.

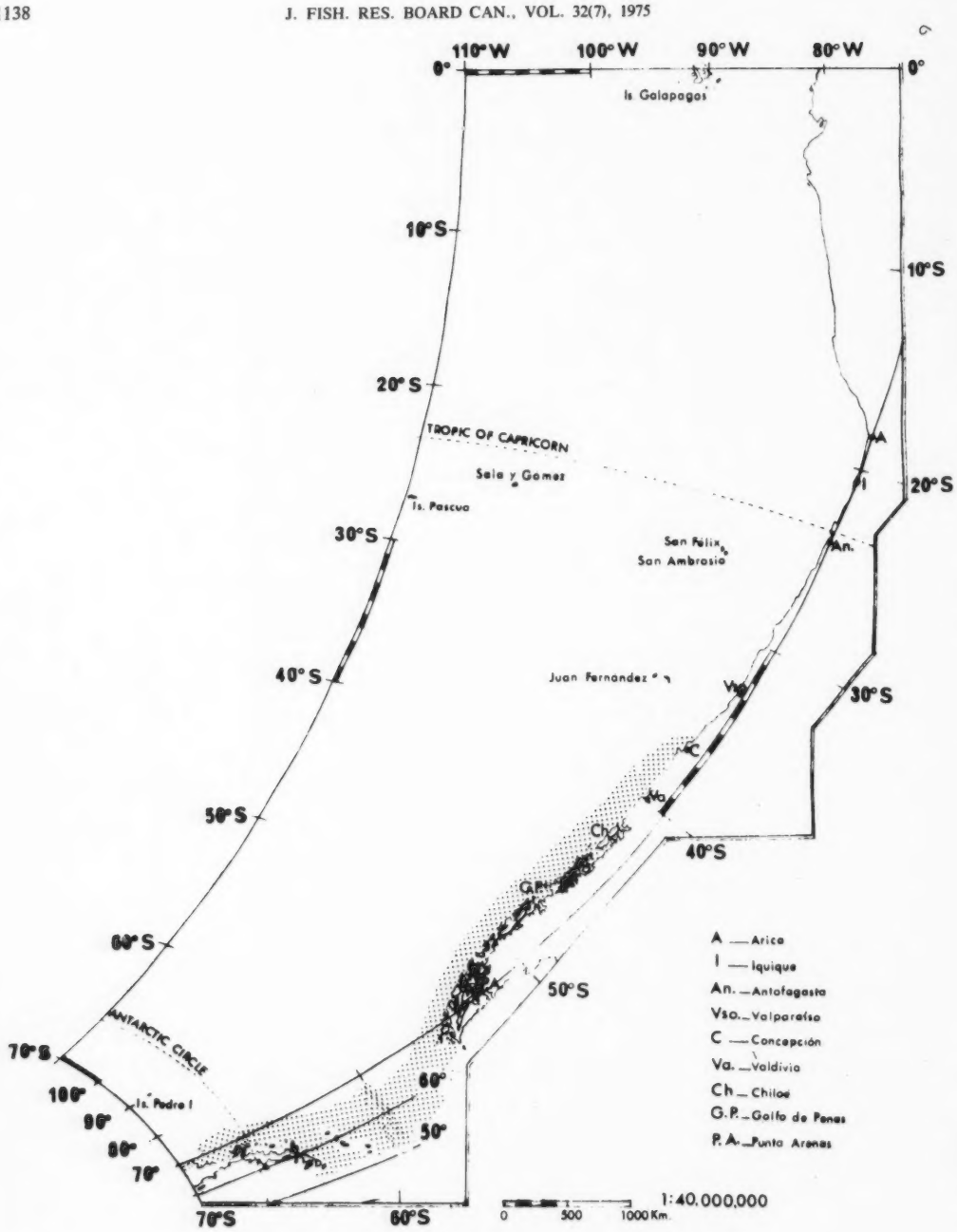

FIG. 20. Actual distribution of *Orcinus orca* in Chilean waters.

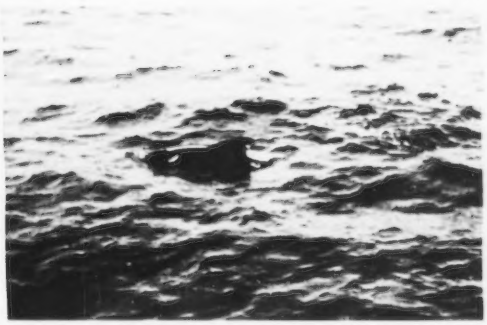

FIG. 21. *Globicephala melaena edwardii* at sea in 28°00'S, 77°55'W, showing its white streak behind the eye, June 1970 (photo by Dr D. Hunsaker Jr.).

of 20 and 9 animals, respectively. Jan. 19, 1973 — Bellinghausen Sea. A single (male) animal. Jan. 31, 1973 — Antarctic Sound. Two schools of 4 and 2 animals, respectively.

Bini (1951) cited this species for Peru in the waters near Chancay. Lévêque (1963) cited this species for Ecuador in the waters of the Galápagos Archipelago.

The dorsal fin and the coloration of this large dolphin are very useful for its identification at sea.

The known distribtuion of this species in Chilean waters is shown in Fig. 20.

Globicephala melaena edwardii (Smith, 1834).
SOUTHERN PILOT WHALE OR BLACKFISH.
CALDERÓN NEGRO OR BALLENA PILOTO.

This pelagic and coastal cetacean was cited for the area by Oliver (1946), Yañez (1948), Mann (1958), Clarke (1962), Aguayo (1966), Norris (1968), and Gilmore (1971). Oliver (1946) stated that this animal appears occasionally in the littoral of Concepción at the beginning of summer.

Clarke (1962) pointed out that the blackfish sighted on the coast of Chile, comprising altogether 198–213 animals, extended all across the main body of the Humboldt Current from 15 to as far as 150 miles from the coast. He noted that there were between 5 and 100 individuals to a school, although most schools were comprised of 10–20 animals. Clarke also cited this cetacean for Ecuador as follows: "On the equatorial voyage the comparatively few blackfish (32) were seen a good distance (40–60 miles) from the continental coast of Ecuador and once at 50 miles from the mouth of the Gulf of Guayaquil; in these waters the schools were smaller comprising as few as two and not more than 12 animals."

Lévêque (1963) cited also *Globicephala* sp. for Ecuador in the Gulf of Guayaquil and in the waters between the Galápagos Archipelago and the continental coast of Ecuador. Aguayo (1966) observed about 230–240 *Globicephala* between 33°S and 49°S (see Table 1). Aguayo (unpublished) also observed a school of 45 pilot whales about 25 miles off Paita, Peru, on July 10, 1959. Norris (1968) observed a school of 15 blackfish in the Golfo de Penas on November 21 and also collected 11 specimens in the fjord region. Gilmore (1971) observed this dolphin near Mocha Island and again far at sea, a half-day's run south of San Ambrosio Island.

The color of the pilot whales I have observed in Chilean and Peruvian waters is black, but there are three white areas; on the chest, behind the dorsal fin, and behind the eyes (Fig. 21 and 22).

The blackfish is one of the most abundant smaller cetaceans off the Chilean coast and it is probable that in the near future this animal will become part o. the Chilean whale catch. The known distribution of this species in Chilean waters is shown in Fig. 23.

Family Phocoenidae

Phocoena spinipinnis is the only member of this family known to occur in Chilean waters.

Phocoena spinipinnis Burmeister, 1865.
BURMEISTER'S PORPOISE. MARSOPA ESPINOSA OR CHANCHO MARINO.

This coastal species was cited for the area by Fraser (1937), Oliver (1946), Yañez (1948), Mann (1958), Cabrera (1961), Clarke (1962), and Norris (1968). Fraser (1937) pointed out that this porpoise is rare, ranging from La Plata

FIG. 22. *Globicephala melaena edwardii* at sea, near Mocha Island, showing its white area behind the dorsal fin, March 1966 (photo by A. Aguayo).

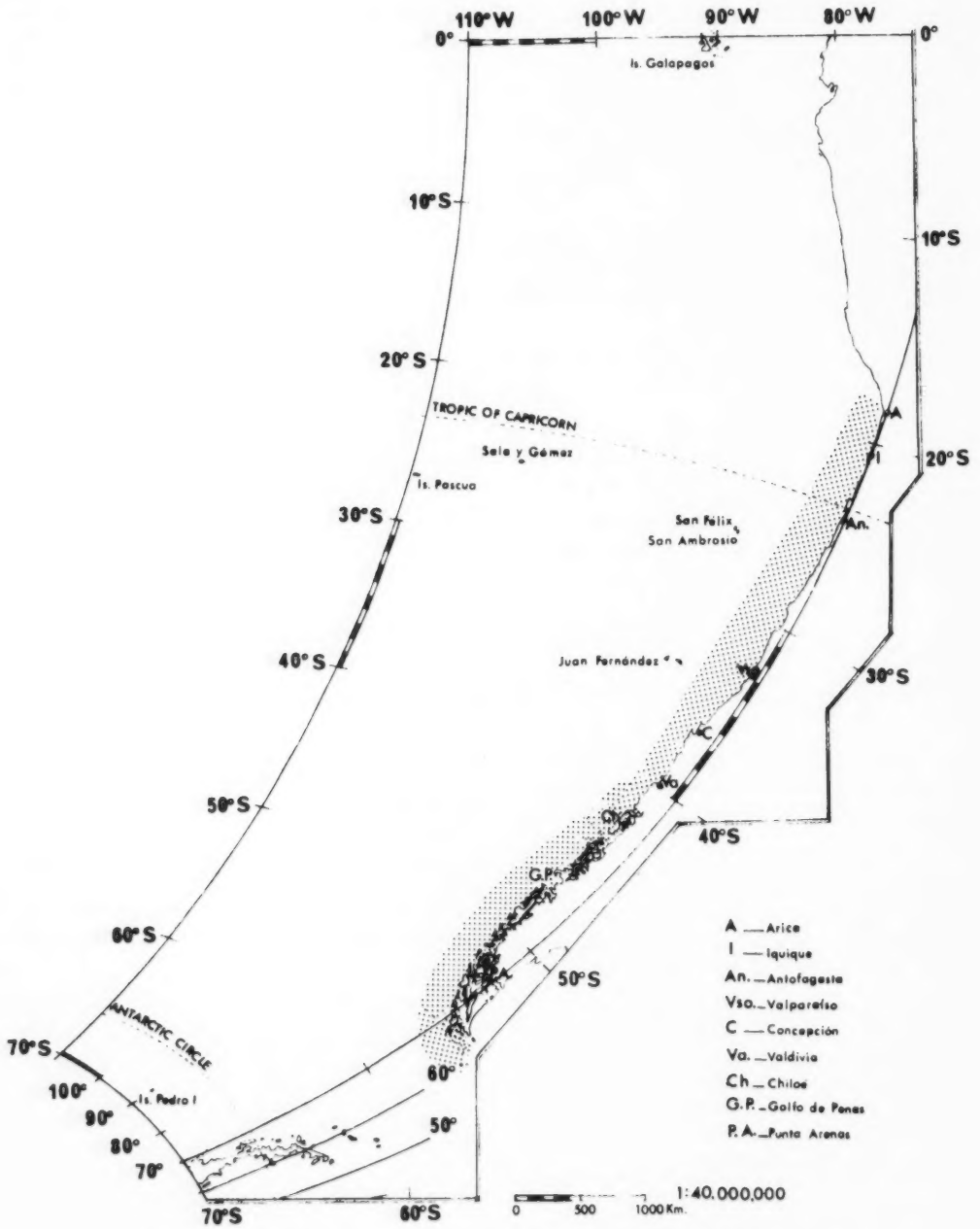

FIG. 23. Actual distribution of *Globicephala melaena edwardii* in Chilean waters.

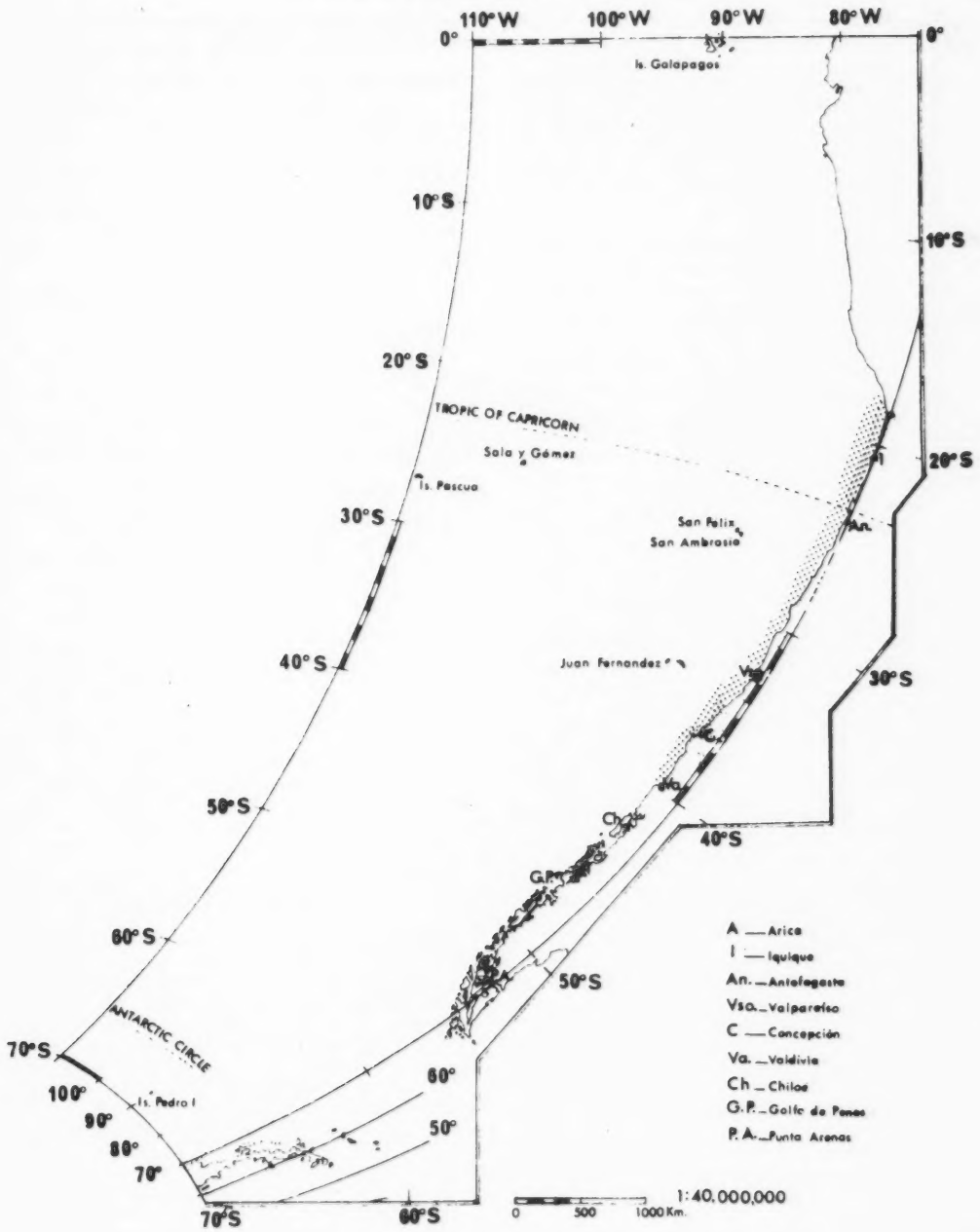

FIG. 24. Actual distribution of *Phocoena spinipinnis* in Chilean waters.

round the Horn to Peru. Clarke (1962) cited it only for Peru in a footnote as follows:

> "The only other species of dolphin or porpoise I have identified on the west coast of South America is Burmeister's porpoise, ... a specimen of which I examined on 12 June 1960 on the coast of Perú in 09°04′S 78°34′W at the fish-market in Chimbote, where it is commonly offered for sale."

Cabrera (1961, p. 619) pointed out that perhaps *Delphinus lunatus* Lesson and Garnot, observed in Concepción Bay, Chile, on the voyage of the *Coquille* in 1822–25, is a young specimen of this porpoise.

Norris (1968) found that this species was common in the northern part of Chile (Iquique–Antofagasta) and is taken for human consumption. Norris recorded the southern distribution of this porpoise between Concepción (36°50′S) and Valdivia (39°50′S). In Peru, he discovered a fishery of this species amounting to 225,000–300,000 lb per year. Grimwood (1969) stated that *Phocoena spinipinnis* is frequently caught by small boat fishermen along the Peruvian coast and were on sale every day at San Andrés (13° 50′S) and other fish markets.

I observed this porpoise on only one occasion at the mouth of Loa River (21°25′S) on October 10 and 11, 1965, when I was making a census of sea lions (*Otaria flavescens*) in the north part of Chile. I saw a school of eight animals. The largest was about 1.7 m long, completely dark, and with knobs on the anterior border of the dorsal fin. Fishemen of Iquique and Antofagasta informed me at that time that from time to time they used this animal as human food, between Arica (18°S) and Coquimbo (30°S).

The known distribution of this species in Chilean waters is shown in Fig. 24.

Summary

To date, the following smaller cetaceans of the families Delphinidae and Phocoenidae have been recorded with certainty from Chilean waters:

Commerson's dolphin (*Cephalorhynchus commersonii*)
Black or Chilean dolphin (*Cephalorhynchus eutropia*)
Common dolphin (*Delphinus delphis*)
Southern right whale dolphin (*Lissodelphis peronii*)
Peale's porpoise (*Lagenorhynchus australis*)
Southern striped or Fitzroy's dolphin (*Lagenorhynchus obscurus*)
Hourglass dolphin (*Lagenorhynchus cruciger*)
Southern bottlenose dolphin (*Tursiops* sp.)
Risso's dolphin (*Grampus griseus*)
Killer whale (*Orcinus orca*)
Southern pilot whale (*Globicephala melaena edwardii*)
Burmeister's porpoise (*Phocoena spinipinnis*)

Several small dolphin fisheries exist and in the near future a fisheries for pilot whale may start in Chile and in Peru.

Resumen

Doce especies de delfines o tuninas pertenecientes a las familias Delphinidae y Phocoenidae se han identificado con certeza hasta la fecha, Septiembre de 1973, en aguas chilenas:

Tunina overa o Delfín de Magallanes (*Cephalorhynchus commersonii*)
Tunina negra o Delfín chileno (*Cephalorhynchus eutropia*)
Delfín comun (*Delphinus delphis*)
Delfín liso o Delfín de Péron (*Lissodelphis peronii*)
Llampa o Delfín austral (*Lagenorhynchus australis*)
Delfín listado o Delfín de Fitzroy (*Lagenorhynchus obscurus*)
Delfín cruzado (*Lagenorhynchus cruciger*)
Tunina de la islas o Tursion (*Tursiops* sp.)
Falso calderón o Delfín gris (*Grampus griseus*)
Calderón negro o Ballena piloto (*Globicephala melaena edwardii*)
Orca o Ballena asesina (*Orcinus orca*)
Marsopa espinosa o Chancho marino (*Phocoena spinipinnis*)

A lo largo de la costa de Chile existen algunas capturas accidentales de delfines realizadas por los pescadores artesanales de Arica, Iquique, Antofagasta, Coquimbo, Valparaíso, Talcahuano, y Valdivia. La carne de los delfines es usada por los pescadores como carnada y para el consumo humano.

En un futuro cercano las capturas del Calderón negro y otras especies de delfines se harán a escala industrial tanto en Chile como en el Perú.

Acknowledgments

I wish to express my gratitude to the University of Chile, Chilean Antarctic Institute, and the Ministry of Agriculture of Chile, because they made possible my observations on marine mammals in my country.

I also thank Drs K. S. Norris and R. M. Gilmore for their great help during the cruises on board R/V *Hero* in 1968 and 1970 in Chilean waters, respectively, and to Commander J.-Y. Cousteau for his kind invitation to participate on the Chilean leg of the southern cruise of the R/V *Calypso* during the summer season 1972–73. To my Chilean colleagues Dr R. Maturana and Prof. D. Torres, of the Ministry of Agriculture and University of Chile, respectively, I am indebted for their help in my observations at sea. Dr D. Hunsaker Jr., of the University of California and Mr T. Antezana of the University of Chile, kindly made available the slides of *Globicephala* and *Lagenorhynchus*, respectively. Mrs S. Urbina L., of the University of Chile, Valparaiso, helped with her editorial suggestions. Mr J. Ibañez A., of the Swedish

Museum of Natural History, Stockholm, supplied the maps of the present contribution from The Time Atlas of the World (Vol. V, Plate 120).

Mr R. L. Brownell Jr. also read and commented on my paper.

Finally, I wish to express my gratitude to the Swedish Government for granting a fellowship that allowed me to continue my work on marine mammals research at the Swedish Museum of Natural History, Department of Vertebrates, Stockholm.

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Modified Leslie–DeLury Population Models of the Long-Finned Pilot Whale (*Globicephala melaena*) and Annual Production of the Short-Finned Squid (*Illex illecebrosus*) Based upon their Interaction at Newfoundland[1]

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MERCER, M. C. 1975. Modified Leslie–DeLury population models of the long-finned pilot whale (*Globicephala melaena*) and annual production of the short-finned squid (*Illex illecebrosus*) based upon their interaction at Newfoundland. J. Fish. Res. Board Can. 32: 1145–1154.

Distributions and seasonal movements of *Globicephala melaena* and *Illex illecebrosus* evince similar patterns and the cetacean feeds almost exclusively on the cephalopod while inshore at Newfoundland. Peaks in Newfoundland landings of both species are coincident and this is taken to indicate that availability of pilot whales inshore depends on that of short-finned squid. Progressively higher peaks in squid landings with progressively lower peaks in whale landings are interpreted to indicate depletion of the whale populations. Utilizing squid landings as a correction for availability of whales, closed system models are generated to estimate the initial population size of the exploited pilot whales at less than 60,000. Estimates of potential squid consumption by these stocks indicate that annual squid production may be in the order of several hundred thousand tons.

MERCER, M. C. 1975. Modified Leslie–DeLury population models of the long-finned pilot whale (*Globicephala melaena*) and annual production of the short-finned squid (*Illex illecebrosus*) based upon their interaction at Newfoundland. J. Fish. Res. Board Can. 32: 1145–1154.

La répartition et les mouvements saisonniers de *Globicephala melaena* et *Illex illecebrosus* ont des modalités semblables, et le cétacé se nourrit presque exclusivement du céphalopode lors de son séjour dans les eaux côtières de Terre-Neuve. Les pics de capture des deux espèces à Terre-Neuve coïncident, et ceci est considéré comme indication que la disponibilité du globicéphale noir près de la côte dépend de celle de l'encornet. Des pics progressivement plus élevés dans les débarquements d'encornets et progressivement plus bas dans la capture des baleines sont considérés comme signes de diminution de la population de baleines. Utilisant les débarquements d'encornets comme facteur de correction de la disponibilité des baleines, nous construisons des modèles de systèmes clos qui nous permettent d'estimer à moins de 60,000 la population originale de globicéphales noirs exploitées. Les estimés de la consommation potentielle d'encornets par ces stocks indiquent que la production annuelle d'encornets peut être de l'ordre de plusieurs centaines de mille tonnes.

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BOTH *Globicephala melaena* and *Illex illecebrosus* are seasonal migrants to Newfoundland inshore waters, the two arriving and departing almost simultaneously and the cetacean feeding almost exclusively on the cephalopod. Availability of both species inshore has been sporadic and fisheries for both have shown wide fluctuations in landings. Does the abundance of whales inshore correlate with that of squid and if so does the recent collapse of the pilot whale fishery relate to dearth of squid inshore and/or to overexploitation of the whale stocks? What can be deduced regarding population sizes of each through a study of their interaction?

Sergeant (1962) has ascribed the short-term decline in whale landings in years immediately subsequent to 1956 principally to hydrographic factors (these being taken to reduce availability of squid inshore) while, in assessing a much longer series of landings data, Mitchell (1974) considered that the fishery severely depleted the stocks, this

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assumption being the basis of his estimate of initial population size from a cumulative catch plot.

Recent estimates of the standing stock of *Illex illecebrosus* have ranged to hundreds of thousands of tons (Gulland 1971; Voss 1973); however, these estimates are guesses rather than being derived from any detailed assessment of the resource.

This paper reviews distribution, seasonal abundance, and trophic relations of the two species, describes the fisheries, and assesses correlations between landings. The implications of these correlations are discussed and utilized in the estimation of stock size of the whale and annual production of the squid.

Distribution

Geographic Ranges

Long-finned pilot whale — This cetacean is recorded from Iceland (Saemundsson 1939) and Greenland (Brown 1868; Jensen 1928; Sergeant 1968) southward to New England. The only positive *G. melaena* from New Jersey are two specimens examined by Ulmer (1961). A single extralimital stranding was noted from Virginia (Paradiso 1958). Recently McGrath and Thomas (1973) listed records from Assateague Island, Virginia, Nags Head, North Carolina, and Grassy Key, Florida; pending verification it must be considered that these could have related to *Globicephala macrorhynchus*, a species which did not occur in their long list of sightings and strandings. Davies' (1960) distribution map indicates an eastern Atlantic range extending from the Barents Sea to northwest Africa. The species apparently has a continuous distribution across the deep waters of the North Atlantic (Brown 1961).

Short-finned squid — While the short-finned squid has also been recorded at West Greenland (Posselt 1898) and Iceland (Gröndal 1891), there are no published 20th century records of the species there and reported occurrences require confirmation (Mercer 1968). The species does range at least from Labrador (Squires 1957) to Florida (Roper et al. 1969) and it occurs southwards to the area of the Bristol Channel in the eastern Atlantic (Adam 1952). Published records extend from coastal waters to the area of the continental slope with no mid-ocean captures having been noted.

Comparison — While the distribution of the whale and squid are thus broadly confluent, that of the whale may be less restricted by depth so that the two are not sympatric in the oceanic zone. In the North Atlantic both have the most northerly distributions of species in their respective genera and both are replaced by congeners to the south, by *G. macrorhynchus* in the case of the pilot whale and *I. oxygonius* and *I. coindeti* in the case of the short-finned squid. *Globicephala macrorhynchus* feeds on Cephalopoda in captivity (Sergeant 1962) though few details have been published of its natural foods.

Seasonal Movements

Long-finned pilot whale — Globicephala melaena shows marked seasonal variation in its distribution. The earliest recorded arrival date on the Grand Bank is June 27 both in 1953 and 1954 and the whales remain there up to late autumn; an exceptionally late sighting occurred in early January 1953 (Sergeant and Fisher 1957).

The earliest record from Newfoundland coastal waters noted by Sergeant and Fisher (1957) was June 26, 1954, and the latest sighting in Trinity Bay during the period 1951–55 was on November 10, 1954. Mercer (1967) also noted a single sighting of a herd in Trinity Bay in January 1951, and sightings in January and the capture by driving on February 14 of a herd in Trinity Bay in 1967.

Pilot whales are not commonly seen in inshore waters of the Maritime Provinces of Canada or southwards, although some sightings and strandings have been recorded (Sergeant and Fisher 1957; Sergeant et al. 1970).

Summer sightings offshore are widespread off New England (Sergeant unpublished data), Nova Scotia (Mercer 1973a), in the Labrador Sea (Sergeant and Fisher 1957), and over oceanic depths east of the Grand Bank (Brown 1961; Sergeant and Fisher 1957). Three winter (December–March) sightings have been made off New England (39°42′–41°00′N, 70°25′–70°53′W, Mercer 1967), a single overwintering was reported near Godthaab, Greenland (Jensen 1939), and winter records have been noted east of the Grand Bank (Brown 1961; Sergeant and Fisher 1957). While stock relationships of northwest Atlantic pilot whales are not known, Sergeant (1962) has suggested that the main wintering area of the stock fished at Newfoundland is in the waters of the North Atlantic Current, east of the Grand Bank (Fig. 1).

Short-finned squid — Illex illecebrosus is a highly migratory species. It is rarely taken in Canadian Atlantic waters during the winter months and first appears in abundance on the continental shelf in May and June (Squires 1957). Populations visiting Newfoundland inshore waters approach from the south and are taken on the southwestern part of the Grand Bank and on the southern part of St. Pierre Bank in spring prior to reaching the inshore area (Squires 1957, 1959; Mercer 1966, 1973b; Mercer and Paulmier 1974).

Occurrence inshore is generally from July to October or November with outer limits of mid-June to early December. Even during this period squid are known to occur on the continental shelf offshore (Nielsen 1891; Squires 1957). It has been suggested that spawning and subsequent death occur during winter months in waters to the south; however, the relationships of stocks of the species known to occur in winter off the coast of the United States (Mercer 1969a, 1970a) have not yet been described.

Comparisons — It is evident that spring arrival of

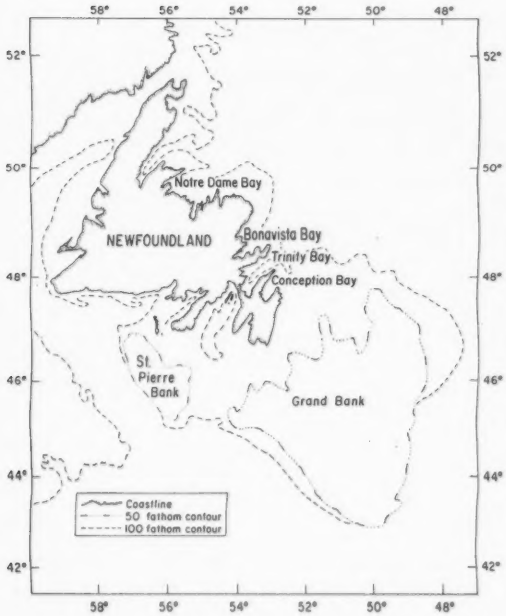

FIG. 1. Newfoundland area indicating place names in the text.

the whales is somewhat later than is that of squid on the Grand Bank. Sergeant and Fisher (1957) suggested that this may be because the squid are in deeper water in May and June. Recent studies by Mercer (1973b) have indicated that, in this period, squid concentrate at the edge of the continental shelf in waters generally warmer than 5° C when vertical dispersal and horizontal movement to shallower areas on the shelf are impeded by overlying cold arctic water. The only winter sighting of pilot whales on the Grand Bank (January 1953) was associated with an unusually late occurrence of squid in the area in a year of marked Gulf Stream influence (Sergeant and Fisher 1957).

Occurrences of both species inshore are nearly coincident, with the whales arriving shortly after the squid and, aside from a few winter records, departing slightly before the last of the squid. It is only in the Newfoundland area of the northwest Atlantic that inshore migrations of both species are regular events.

Trophic Relations

DIET OF THE LONG-FINNED PILOT WHALE

An explanation of the congruences observed in seasonal migrations, particularly to eastern Newfoundland waters, can be seen in the diet of the pilot whale. In observations at Newfoundland from 1951 through 1956 no food items were observed except short-finned squid (Sergeant 1962). In late August 1957, squid rapidly disappeared from inshore areas and they were followed by a majority of the pilot whales; those remaining were reported to be feeding on Atlantic cod (*Gadus morhua*). In 1958 squid were scarce inshore and few pilot whales were taken, these again being reported as feeding on cod (Sergeant 1962). Whale stomachs examined early in the 1959 season contained squid with a small proportion of cod (Sergeant 1962). Aldrich and Bradbury (personal communication) found beaks of both *Gonatus fabricii* and *Illex illecebrosus* in their examination of stomachs of 12 pilot whales at Chapel Arm, Trinity Bay in the late 1960s. The one herd driven in winter was found to have been feeding on the Greenland turbot, *Reinhardtius hippoglossoides* (Mercer 1967). A reported instance of feeding on long-finned squid (*Loligo pealei*) in the Gulf of St. Lawrence (Prefontaine 1930) has been shown to have resulted from misidentification of the short-finned squid (Mercer 1970b).

It is evident, then, that squid is the preferred diet of pilot whales in the Newfoundland area with fish being taken as an alternative when squid are not available.

FEEDING RATE OF THE LONG-FINNED PILOT WHALE

From stomach contents examined at Newfoundland Sergeant (1962) stated that an average-sized pilot whale 3.96 m long and weighing about 830 kg appears to require 11–14 kg of food to fill its stomach. Limited observations indicated a digestion time of less than 8 h so that daily average consumption from three meals could total 34–41 kg. This is equivalent to a feeding rate of 4.1–4.9% of body weight per day and an annual consumption of 12,410–14,965 kg or 15.0–18.0 times body weight per year, under the assumption that feeding rate remains constant.

As reviewed by Sergeant (1969) the feeding rates of *G. scammoni* observed in captivity (Brown 1960, 1962; Gilmore 1962) were in the order of 4.0–5.9% of body weight per day. Thus the estimates for *G. melaena* above do not appear to be inordinately high, except that feeding rates in aquaria are probably optimal or in some aquaria, to excess, which cannot be the case at all times in nature.

Newfoundland Fisheries

LONG-FINNED PILOT WHALE

According to Templeman (1966) there has been a small amount of exploitation of pilot whales at Newfoundland for several centuries, by the whalers before 1900 and by fishermen who drove

TABLE 1. Landings data utilized in this paper. Eastern Newfoundland refers to Conception Bay, Trinity Bay, and Bonavista Bay. (Pilot whale catches for 1968–69 do not accord with figures in *International Whaling Statistics*, but total is close.)

Year	Pilot whales (no.)	Nfld. squid (10^6 lb)	Eastern Nfld. squid (10^6 lb)
1947	0		
1948	215		
1949	0		
1950	172		
1951	3102		
1952	3155	7.6	
1953	3584	10.0	
1954	2298	14.7	
1955	6612	15.5	9.1
1956	9794	17.2	13.2
1957	7831	5.8	3.7
1958	789	1.6	1.1
1959	1725	6.3	4.3
1960	1957	11.2	7.9
1961	6262	19.8	12.9
1962	150	1.1	.1
1963	221	5.0	3.2
1964	2849	22.9	17.0
1965	1520	17.2	12.7
1966	887	11.1	6.7
1967	739	15.2	12.1
1968	204	.002	0
1969	123	.048	
1970	155	.2	
1971	4	5.5	
1972	0	.045	

herds ashore and utilized those that stranded naturally. The modern industry began in 1947 at Dildo, Trinity Bay, when a factory was established and two small catchers started harpooning pilot, minke, and a few large whales (Sergeant 1953). From 1951 on, nearly all pilot whales were taken by driving, with a variable number of animals, generally only a few hundred annually, being harpooned from the catcher vessels at times when circumstances made driving impossible (Sergeant 1962). While most of the pilot whales landed were taken in Trinity Bay, large numbers were also captured in Bonavista Bay and a few in Notre Dame Bay (Sergeant 1962). Landings (Table 1) fluctuated considerably, reaching a peak of 9799 in 1956 and lower peaks in 1961 and 1964. Catches were negligible after 1968. The fishery ended when commercial whaling on the Canadian Atlantic coast was banned by the Government of Canada on December 22, 1972.

SHORT-FINNED SQUID

A trawl fishery for squid developed in the area of the Midatlantic Bight off the coast of the United States beginning in 1968. While this fishery focused initially on the long-finned squid (*Loligo pealei*), landings of short-finned squid have recently increased as a result of directed fishing. Landings in 1972 and 1973 were estimated at 18,000 and 23,000 metric tons, respectively. Squid taken on the continental shelf in the Canadian Atlantic are almost exclusively short-finned squid. Landings reported 1971–73 were 7284, 1842, and 9220 metric tons; no figures are available for earlier years.

The species has historically supported summer and fall inshore fisheries at the northern extreme of its western Atlantic range, particularly at Newfoundland where recent annual landings have ranged from 1 to 10,500 metric tons. While the fishery probably dates back to the days of first settlement and the early cod fisheries, statistics on landings are available only for recent years. Squires (1957) collated data from various sources and presented a histogram of relative annual abundance for the period 1879–1954. Total landings are available in the "Fisheries Statistics of Canada" beginning in 1952. A breakdown by area is also available for 1955–68 and by month for 1956 to present; these data have been recently summarized (Mercer 1973c).

TABLE 2. Correlation coefficients and significance probabilities relating long-finned pilot whale (*Globicephala melaena*) catches to short-finned squid (*Illex illecebrosus*) catches at Newfoundland, A — using total squid landings for Newfoundland, B — using squid landings for Conception Bay, Trinity Bay, and Bonavista Bay. The rationale for choice of particular years is as follows: 1952 — first year for which squid landings figures are available; 1955 — first year for which regional breakdowns of squid landings are available; 1956 — year of peak pilot whale landings; 1964 — year in which mechanized squid jiggers were introduced; 1972 — last year of commercial whaling at Newfoundland.

Period	*r*	df	*t*	1-sided	2-sided
A					
1952–56	.6778	3	1.5967	$.10<P<.15$	$.20<P<.30$
1957–64	.4262	6	1.1540	$.10<P<.15$	$.20<P<.30$
1952–64	.5145	11	1.9900	$.025<P<.05$	$.05<P<.10$
1952–72	.5448	19	2.8319	$.005<P<.01$	$.01<P<.02$
B					
1955–64	.5307	8	1.7710	$.05<P<.10$	$.10<P<.20$
1955–68	.4194	12	1.6004	$.05<P<.10$	$.10<P<.20$

The Newfoundland fishery is passive. It is based on availability of squid to jigging devices in inshore waters of less than about 20 m depth. Fluctuations in catch reflect not only variations in recruitment but variations in local distribution in relation to environmental parameters and variation in behavior with regard to jigs (Mercer 1971). Jigs traditionally employed were single painted lead lures bearing a circlet of barbless hooks. However, beginning in 1964, mechanized Japanese jigging devices were introduced (Quigley 1964) and these quickly supplanted traditional jiggers. When squid are abundant, these devices allow a several-fold increase in catch per man-hour. A few stationary traps have also been employed on the southeast coast, but these account for a very small proportion of total landings.

Unfortunately, no measure of effort is available for the inshore fishery and, in employing landings (Table 1) as a measure of availability of squid inshore, one cannot adjust quantitatively for changes in effort or gear efficiency.

Correlations — Knowing that pilot whales eat short-finned squid, one could suggest that the availability of whales and of squid inshore are correlated and, if effort expended in both fisheries were constant, that the correlation would extend to catch figures. Correlation coefficients relating whale landings to those of squid were calculated for various periods within the years 1952–72 (Table 2). The one-sided test is appropriate as a positive correlation was expected by prior hypothesis. The coefficients associated with significant probability values were found to be those for longer periods. The correlation between landings of the species stems from the predator–prey relationship.

Assuming, then, that prey abundance is the sole determinant of pilot whale abundance inshore, then a perfect correlation between catch figures could be obtained only if the fisheries did not deplete either stock. Comparison of graphs of landings indicates otherwise (Fig. 2). Peaks in

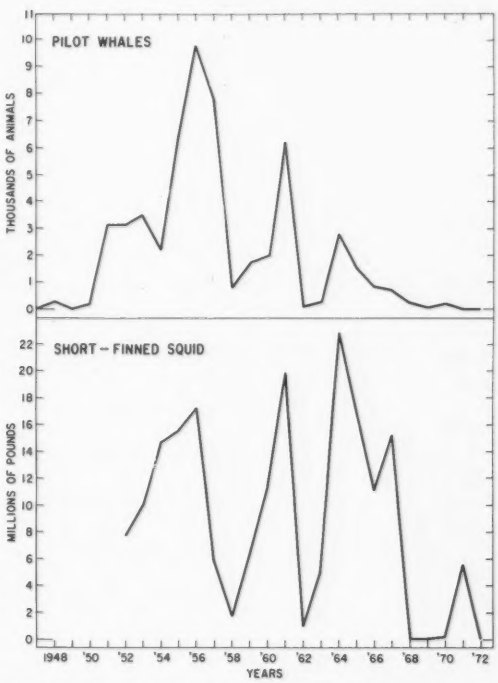

FIG. 2. Newfoundland landings of short-finned squid (*Illex illecebrosus*) and the long-finned pilot whale (*Globicephala melaena*).

pilot whale landings in 1956, 1961, and 1964 show a declining trend and, while peaks in squid landings coincide in time, the opposite trend obtains with highest landings being made in 1964. This is interpreted to indicate depletion of the pilot whale stocks, an argument that will be further developed in the following section.

Assessments

Stock Size of the Long-Finned Pilot Whale

The foregoing correlation can now be utilized in developing models to estimate the initial stock size of pilot whales fished at Newfoundland. Let us assume that for the periods being considered:

1. The effort expended by whale catchers and their efficiency have remained constant.
2. The effort expended on squid has remained constant.
3. The catches of both species are accurate measures of abundance inshore.
4. There is a positive correlation between abundance (as measured by landings) of the two species in the fishing area, and remaining variation in whale abundance (landings) not explained by this correlation is random.
5. No stocks of pilot whales have moved in to occupy grounds formerly occupied by reduced stocks and no emigration has occurred of stocks formerly exploited at Newfoundland.
6. Recruitment and natural mortality of pilot whales have remained equal as is assumed in the virgin stocks.

Closed-system models patterned after those developed by Leslie and Davis (1939) and DeLury (1947, 1951) can then be generated. The following notation is adopted:

t designates the t^{th} year

d_t relative rate at which individuals are removed from the whale population by whaling

c_t number of whales taken in year t

e_t whaling effort in t^{th} year, taken to be constant from year to year

a_t catch of squid in year t, a correction factor for availability of whales

$A_t = a_1 + a_2 + \ldots a_{t-1}$ the total squid catch up to the start of year t

$C_t = c_t/e_t$ the catch of whales per unit of effort in year t

$K_t = c_1 + c_2 + \ldots c_{t-1}$ the total whale catch up to the start of year t

$E_t = e_1 + e_2 + \ldots e_{t-1}$ the total whaling effort up to the start of year t

k_t catchability of whales during year t, i.e. the proportion of the whale population taken per unit of effort

N_t size of the whale population at the start of year t

$N = N_1$ whale population size at the beginning of the sampling period when $K_t = E_t = 0$.

Model I

From the definitions

$C_t = k_t N_t$, if units of effort do not compete. (1)

In the DeLury model one would now designate $k_t = k$, a constant throughout the sampling period. The present model requires a correction for availability, a parameter that has been shown to be correlated with squid abundance.

$k_t \propto a_t$
Let D be the constant of proportionality
Then $k_t = Da_t$
or $D = k_t/a_t$
Since the population is considered to be closed then
$N_t = N - K_t$
So that the equation (1) can be rewritten
$C_t = Da_tN - Da_tK_t$ or

$$\frac{C_t}{a_t} = DN - DK_t \tag{2}$$

If the assumptions hold, then a plot of the values of C_t/a_t against those of K_t yields a straight line with intercept DN and slope $-D$ from which N can be calculated by simple division.

Model II

Since we assume no net additions to or subtractions from the population, except by fishing, the net change in population size in the interval $(t, t + dt)$ is given by:

$N_t[-d]dt$ which may be equated to $N(t + dt) - N_t$
Dividing by dt and passing to the limit as dt approaches zero

$$\frac{dN_t}{dt} = -N_t d_t \text{ or}$$

$$\frac{d}{dt} \ln N_t = -d_t \tag{3}$$

Now $d_t = k_t e_t$ by assumption
and $k_t = Da_t$ as indicated in Model I
$\therefore d_t = Da_t e_t$ (4)

Under the given assumptions (3) becomes

$$\frac{d}{dt} \ln N_t = -Da_t e_t$$

which upon integration gives

$$\ln N_t - \ln N_o = -De_t \int_0^t a_t dt = -De_t A_t$$

which can be written

$$N_t = N_o e^{-De_t A_t} \quad (5)$$

Since $C_t \simeq d_t N_t$

$\therefore$ from (4) and (5)

$$C_t = Da_t e_t N_o e^{-De_t A_t}$$

$$\frac{C_t}{a_t} = De_t N_o e^{-De_t A_t}$$

$$\ln\left(\frac{C_t}{a_t}\right) = \ln De_t N_o - De_t A_t$$

If a plot of $\ln (C_t/a_t)$ against A_t gives a straight line the intercept is $\ln De_t N_o$ and the slope $-De_t$ from which N_o can be derived.

MODEL III

This model can be generated after Sandeman (1969) as follows:

$$N_t = N_o - \sum_1^t c_t \quad (6)$$

The instantaneous decrease of the population is proportional to the number present.

$$\frac{dN}{dt} = -qN$$

which yields on integration

$$N_t = N_o e^{-qt} \quad (7)$$

Thus from (6) and (7)

$$N_o - \sum_1^t c_t = N_o e^{-qt}$$

$$\text{or } \sum_1^t c_t = N_o(1 - e^{-qt})$$

Thence by substituting $t + 1$ for t and subtracting the resulting equation from it

$$\sum_1^{t+1} c_t = N_o(1 - e^{-q}) + \sum_1^t c_t e^{-q} \quad (8)$$

With N and q constants a plot of

$$\sum_1^{t+1} c_t \text{ versus } \sum_1^t c_t$$

yields a straight line with intercept $N_o(1 - e^{-q})$ and slope e^{-q} from which N can be calculated.

Results — Since the assumptions underlying the closed-system models do not permit net change in population size except through fishing, the minimum allowable estimate of initial population size must exceed the cumulative catch. For the period 1947–71 this was 54,348.

Population estimates derived from Model I vary between 66,273 and 99,183 for the start of the 1947 fishery (Table 3). Elimination of values derived from poorly fitted lines ($P > .10$) yields estimates of 66,273 and 75,361 with a mean of 70,817. Estimates derived from Model II are 49,142–54,806 with a mean of 52,618, while those from Model III are 62,516–79,592 with a mean of 69,926. The overall mean estimate derived from all well-fitted ($P < 0.10$) lines in the three models is 62,432.

Discussion — Studies were undertaken by Sergeant in 1957, following the record catch in the previous year, to determine whether any changes had taken place in the composition of the herds and in the growth rates and reproductive frequency of the population which might indicate a population decline. While no such changes were found (Sergeant 1962), such density-dependent responses would be expected to require a longer period than 4 yr (the mean time between his two studies) in a species with a generation time of 6 yr.

Since hunting of pilot whales was almost completely nonselective, except for a small amount of selective harpooning of large animals (Sergeant 1962), two usual criteria of the degree of fishing pressure — the increase in total mortality at ages fished commercially and the reduction in size of the average animal killed — are not available for the pilot whale (Templeman 1966). Sergeant (1962) has suggested that a lowering of population levels by hunting could allow a decline in natural mortality rates; however, only one estimate of natural mortality has been made (for 1954).

Mitchell (1974) had a larger series of catch data available than did Sergeant (1962) and considered that the stock fished at Newfoundland was severely depleted by the fishery. He used the cumulative catch of 47,078 in 1951–61 to estimate an initial population size of about 50,000 which is slightly lower than the mean estimate presented here.

The robustness of the foregoing models could be studied with respect to errors introduced by possible trends, or abrupt shifts, in parameters introduced as constants in the assumptions. One possible error relates to the introduction of mechanized squid jiggers in 1964. The increase in gear efficiency, other factors being equal, would result in a higher squid catch in relation to the squid stock available. This would cause an overestimate of availability of whales and be equivalent in the models to a decrease in catchability. Braaten (1969) has indicated that a decrease in catchability results in a decrease in the estimate of initial population size. The lower estimate in

TABLE 3. Population estimates for long-finned pilot whale stocks fished at Newfoundland as computed from models derived in the text. Raw data are given in Table 1.

Model	Area	Period	Slope	Intercept	r	t	P 1-sided	N_0	N_{1947}
I	All Nfld.	1952–64	−0.0053	507.1801	−0.2618	−0.8997	$.15<P<.20$	95,694	99,183
		1952–67	−0.0075	539.0394	−0.4044	−1.6544	$.05<P<.10$	71,872	75,361
	E. Nfld.	1955–64	−0.0141	1046.5092	−0.2694	−0.7912	$.20<P<.25$	74,221	86,747
		1955–67	−0.0216	1160.9316	−0.4474	−1.6592	$.05<P<.10$	53,747	66,273
II	All Nfld.	1952–64	−0.0106	6.2683	−0.4859	−1.8438	$.025<P<.05$	49,772	53,261
		1952–67	−0.0129	6.3783	−0.6937	−3.6037	$.0005<P<.005$	45,653	49,142
	E. Nfld.	1955–64	−0.0255	6.9830	−0.4661	−1.4901	$.05<P<.10$	42,280	54,806
		1955–67	−0.0289	7.0710	−0.7157	−3.3987	$.0005<P<.005$	40,738	53,264
III	All Nfld.	1952–64	0.9280	5479.8803	0.9837	18.1457	$\ll .0005$[a]	76,103	79,592
		1952–67	0.9031	6219.1899	0.9888	24.7976	$\ll .0005$	64,182	67,671
		1952–72	0.8997	5920.3758	0.9900	30.5833	$\ll .0005$	59,027	62,516

[a]Regression analysis was used to obtain an objective fit, no mathematical significance being attached to these probability values.

each set is that including post-1964 data (Table 3), this being consistent with the presence of the foregoing bias.

The models assume that no trends exist in recruitment and natural mortality and that there is no net emigration or immigration. These studies could now be made only by catching of animals at sea. Such constraints disallow the possibility of recovery of a depleted population and as such would not be expected to apply in nature. In response to heavy exploitation one could anticipate an increase in recruitment through earlier maturation and higher pregnancy rates, a decrease in natural mortality, and net immigration from contiguous stocks. Holding these parameters constant in the models would have the effect of producing an upward bias in the estimate of initial population size. It should thus be considered that the values generated are high and that the initial population size was probably less than 60,000.

While the source of this population is unknown there is presently no evidence of other than local depletion (e.g. sightings in Brown 1961; Brown et al. 1971). If Sergeant (1962) is correct in his suggestion of a wintering area east of Newfoundland, it may be that populations near Greenland, south of Newfoundland to New England, and in the central and east Atlantic have not been affected by the Newfoundland fishery and are not counted in the above estimates. Annual catches of 300–1700 have apparently not damaged the stock fished at the Faeroe Islands (Mitchell 1975).

ANNUAL PRODUCTION OF THE SHORT-FINNED SQUID

Calculations — The amounts of squid consumed in the approximately 100-day season inshore and throughout the year for a range of initial stock sizes of the pilot whale have been calculated, based upon a single-species diet for pilot whales and the range of feeding rates mentioned (above, and Table 4). Consumption estimates for the 100-day season are 166,000–249,000 metric tons for an initial population of 50,000 whales; annual consumption for this population is estimated at 605,900–908,850 metric tons. Higher estimates are generated in utilizing higher initial population estimates (Table 4).

Discussion — It is thought that the short-finned squid has a 1-yr lifespan and dies after spawning (Squires 1967). If this is the case, then an estimate of annual production relates simply to stock size.

It is important to evaluate the constraints relating to the foregoing estimates. The consumption estimate for the 100-day season assumes that the entire whale stock is feeding exclusively on squid. While this condition generally appears to be fulfilled for pilot whales inshore, only part of the whale population is available inshore at any one time; the estimate thus assumes that the remaining whales are also feeding on squid. The congruence in seasonal distribution of the two species on the continental shelf near Newfoundland supports this assumption but it has not been verified by published data.

The validity of extrapolation to estimate annual consumption is subject to the reservations introduced in discussion of the wintering areas of the pilot whales involved. If the species is feeding pelagically in winter in the warm waters of the North Atlantic Drift east of Newfoundland, then *Illex illecebrosus* would not be expected to be available to it; the diet might then be oceanic

TABLE 4. Possible consumption rates of short-finned squid (metric tons) by long-finned pilot whale stocks fished at Newfoundland for various levels of whale population size and consumption rates and assuming a one-species diet for the specified periods.

	Feeding rate			
	4%/day		6%/day	
No. whales	100 days	1 yr	100 days	1 yr
50,000	166,000	605,900	249,000	908,850
60,000	199,200	727,080	298,800	1,090,620
70,000	232,400	848,260	348,600	1,272,390
80,000	265,600	969,440	398,400	1,454,160

squids (including other species of ommastrephids) and oceanic fishes.

Reservations discussed in the foregoing two paragraphs thus indicate likely sources of high bias in the consumption estimates. Other constraints to the analysis introduce low bias.

While heterogeneity has been found in mantle length compositions of short-finned squid sampled at Newfoundland, it has been suggested that a single year-class only is present and the heterogeneity has been suggested to relate possibly to a protracted spawning season and area (Mercer 1969b). The heterogeneity observed between areas inshore (Mercer 1969b) and on the continental shelf (Mercer 1973b) indicates that pilot whales feeding at southeastern Newfoundland are sampling only that part of the squid population comprising larger, more northward-migrating animals. Squid on the Newfoundland south coast, inshore at Nova Scotia and New England, and on the continental shelf in these areas would also be subject to predation by pilot whales. If pilot whale stocks in these areas are not estimated in the foregoing assessment, then short-finned squid consumption by pilot whales for the entire northwest Atlantic could be much higher than figures tabulated for the stock investigated here.

Figures for consumption of short-finned squid discussed in this paper are estimates for only one predator and do not include consumption by other odontocetes, seabirds, or fish predators such as the bluefin tuna (*Thunnus thynnus*) which also feeds heavily on short-finned squid (Butler 1971). It thus appears that annual production of the short-finned squid in the northwest Atlantic can be conceivably estimated as at least several hundred thousand tons. Because of the short lifespan the maximum sustainable yield is probably a high proportion of the standing stock, the principal constraint being maintenance of adequate spawning stock.

Conclusions

The distributions and migrations of the long-finned pilot whale and the short-finned squid show similar patterns and the cetacean feeds heavily on the cephalopod. Availability of pilot whales to the shore-based whaling operation at Newfoundland was closely correlated with the widely fluctuating abundance of squid inshore. Intensive hunting, particularly in the period 1951–61, has severely depleted these pilot whale stocks and released a large surplus production of squid to other predators, including fisheries. In contrast to the overexploited status of the pilot whale, the large squid resource has remained virtually untapped by past and present fisheries.

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Preliminary Report on the Former Net Fisheries for *Tursiops truncatus* in the Western North Atlantic[1]

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MEAD, J. G. 1975. Preliminary report on the former net fisheries for *Tursiops truncatus* in the western North Atlantic. J. Fish. Res. Board Can. 32: 1155–1162.

The net fishery for *Tursiops truncatus*, the bottlenose dolphin, is relatively well documented at Cape Hatteras, less so at Cape May. The Cape Hatteras fishery peaked in 1885–90, with catches of 2000 and more per annum. Catches were largest during fall and spring months; few porpoises remained, or were caught, in the area in summer. School size was up to 600, with a nearly equal sex composition but a wide size range in spring. Possibly there was more segregation in fall. Fetal lengths reported might indicate two breeding peaks. The present status of the population is not known.

MEAD, J. G. 1975. Preliminary report on the former net fisheries for *Tursiops truncatus* in the western North Atlantic. J. Fish. Res. Board Can. 32: 1155–1162.

La pêcherie au filet de *Tursiops truncatus* est relativement bien documentée au cap Hatteras, moins bien au cap May. La pêcherie du cap Hatteras atteignit un sommet en 1885–90, avec prises annuelles de 2000 et plus. Les prises étaient à leur maximum pendant les mois d'automne et de printemps; très peu de dauphins séjournaient ou étaient capturés dans la région en été. Les bancs pouvaient comprendre jusqu'à 600 individus, avec proportion des sexes à peu près identique, mais gamme étendue de taille, au printemps. Il est possible qu'il y ait eu plus grande ségrégation en automne. Les longueurs signalées pour les foetus peuvent indiquer deux pics de reproduction. On ignore le statut actuel de la population.

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SEVERAL small whale fisheries have operated along the Atlantic coast of the United States. The most consistent and economically important of these was the Cape Cod pilot whale fishery. This fishery was in existence in the mid-1700s and continued into the early 1900s, with an apparent peak in the 1870s and 1880s, when catches of up to 2000–3000 *Globicephala melaena* per year were recorded (Clarke 1887a). There are also indications that harbour porpoises (*Phocoena phocoena*) and Atlantic white-sided dolphins (*Lagenorhynchus acutus*) were occasionally taken in this area (Clarke 1887a; U.S. National Museum files), and Ward (1880) described a porpoise fishery in Maine that may have been based on a combination of these species.

Stearns (1887) briefly described a small harpoon fishery for what was probably the bottlenose dolphin (*Tursiops truncatus*), which operated coincidental to a shark fishery out of Tampa Bay, Fla. There is no clear indication of the extent of this fishery, but it appears to have been small. It is quite likely that local catches of several species of small cetaceans have occurred along with a variety of net and harpoon fisheries. For example, Clark (1887b) recorded a small incidental catch of porpoises in a trap fishery along the Rhode Island coast.

In addition to the above, there were two well-documented net fisheries for the bottlenose dolphin along the Atlantic coast, and a third, poorly known net fishery that may have been based on this species. The most important of these was the fishery at Cape Hatteras, North Carolina (Fig. 1–4; True 1885b, d, e; Townsend 1914a, b). The others were a small fishery at Cape May, New Jersey (True 1884, 1885a), and a very early fishery on the east end of Long Island.

History of Exploitation

The porpoise fishery in the Cape Hatteras area was recorded as having begun in 1797 (Stick 1958), and operated at a moderate level (catches of 400–500 porpoises per year) until 1860 when

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FIGURES 1–4. Fishery for *Tursiops truncatus* at Cape Hatteras, North Carolina.

FIG. 1. Removing a catch of porpoise from a seine, February 10, 1928; FIG. 2. Skinning a porpoise on the beach, February 10, 1928. The melon has been removed, and from the manner of the cuts, the skin is being taken for leather; FIG. 3–4. Porpoises from a catch on February 10, 1928.

it was discontinued, possibly due to the impending Civil War (Clark 1887a; Earll 1887; Stevenson 1904a). The fishery was revived, probably in the season of 1883–84, by Messrs Cooke and Sparks of Philadelphia, and reached its peak in the years 1885–90, closing again in 1893 (Stevenson 1904a, b). From this date, the record of the fishery is less clear. Stevenson (1904b) indicated that as of 1902, the fishery had remained inactive. Townsend (1914b) gave catch figures for the years 1907–14, and indicated that the fishery was then being operated by the William F. Nye Co., of New Bedford, Mass. The Report of the U.S. Fish Commission for 1918 listed 1050 lb of "other aquatic hides" (non-shark) for North Carolina, which may have come from a porpoise fishery. Kellogg (1940) indicated that fishery closed in 1929.

The geographic extent of the Hatteras fishery during various phases of its operation is not clear. Stick (1958) indicated that the fishery began at Ocracoke Inlet in 1797. The bulk of the fishery appears to have operated in the immediate area of Cape Hatteras during the 1880s, and later from 1907–29. He also, however, indicated that porpoise fishing was pursued in the Cape Lookout area, where shore whaling was more active. The United States National Museum contains a large collection of skulls of *Tursiops truncatus* obtained from the Cape Lookout area (Ft. Macon) in December of 1871. The condition of many of these skulls indicates that they were taken from fresh animals, suggesting that a fishery was then in operation. This serves to complicate the catch statistics, since some of them clearly refer to the Cape Hatteras area alone, while others may include the whole of the Outer Banks. For purposes of this paper, the Hatteras fishery is meant to include all of the Outer Banks area, which probably only involved a single migratory porpoise population.

The porpoise fishery in this area was a logical extension of the shore seine fisheries for food fish, which provided the background in fishing technique, and the shore-based whale fishery which provided the background for utilization of marine mammal products.

Fishing Season, Migration

True (1891) stated that porpoise schools were found moving south in the fall, then turning north in the spring, with a few remaining in the area during the summer, although there were apparently not enough to support a summer fishery. Much of this migration was within a hundred yards of the shore, providing the opportunity for a shore-based net fishery.

TABLE 1. Catches of bottlenose dolphin, *Tursiops truncatus*, by month at Cape Hatteras.

	1884–85 Season (True 1891)	1885–86 Season (Stick 1958)
Nov.	246	
Dec.	89	171[a]
Jan.	36	165
Feb.	111	210
Mar.	219	205
Apr.	264	282
May	303	262
Total	1268	1295

[a]Combined catch for November 21 to end of December.

Table 1 gives catch figures by month for the two seasons for which data are available. The data given by Stick (1958) for the 1885–86 season represent the catch of one of the two crews operating. The other crew took 754 porpoise for the same 6-mo period. The catch of 171 in 1885–86 represents the catch from November 21 through the end of December.

In general, the larger catches seem to have been at the beginning and end of the season, the record catch apparently being 618 for the first 2 wk of November 1886. This was taken by one of the three crews operating that season in the Cape Hatteras area (Stick 1958). The highest catch days given by Stick (1958) were also near the ends of the seasons, being 142 on April 23, 1886, and 170 on November 1, 1886. The lower catches during the middle of the season may be due to the greater portion of the population having passed to the south of the area, or, more likely, to inclement winter weather.

The stalked barnacle, *Xenobalanus* cf. *X. globicipitis*, was seen on the trailing edges of the appendages of northward migrating animals in late April and May, but was not present on southbound animals in autumn or winter (True 1891). Animals with these organisms attached were referred to as "Tassel-fins."

Fishing Methods

True (1885e) provided the best description of the technique used during the peak of the fishery. Four to six nets of 18-inch mesh, 100–200 yd long, were carried in as many boats. When a school of porpoise was sighted along the shore, two or more boats set a line of nets outside of

the school, parallel to the shore. When the school had moved between this net line and the shore, nets were set first in front of, then behind the school, enclosing it. The ends of these nets were joined and left in place while the porpoise were swept out and beached using one or more small seines of finer mesh. Clark (1887a) said the outer net was of 11-inch mesh, while the small nets used to sweep the porpoises were of heavy material, 9-inch mesh.

Clark (1887a) described essentially the same technique, while Townsend (1914b) indicated that in the latter phases of the fishery they were using a single net about 1000 yd long, which was set parallel to the shore outside the school, then hauled ashore both in front of and behind the school.

Sparks (1885b) indicated that at some point the Cooke Patent Net was tried in this fishery. This was a large net of 8-inch square mesh with two wings 1000 yd long and 24 ft deep and a bag 120 ft long, 60 ft wide, and 24 ft deep. It was developed for the Cape May porpoise fishery and was set in the path of the school with the wings extending along either side of the school. In the Cape May fishery it was hauled by a steamer, forcing the porpoise into the bag, which was then closed. There is no indication that its use at Hatteras was extensive, perhaps due to the difficulty of operating a steamer along that shore.

Catch Sizes

True (1885c) stated that schools of up to 600 were sometimes surrounded by the large net, of which "50 or 60 are hauled ashore at a time." I would interpret this to mean that the total catch from the school of 600 was 50–60, not that 50–60 were taken with each sweep of the small seines. This is comparable to the figure given by Sparks (1885b) of 25 taken from a set on a school of 250. Thus, with the techniques used during the peak of the fishery, approximately 10% of the school was taken in a set, the remainder escaping by either diving under the net or jumping the cork line.

True (1891) examined five catches during the period May 14–19, 1886, ranging from 14 to 66 animals. Townsend (1914b) mentioned a haul of 33 porpoises in November. A news article in the Grand Rapids, Mich., *Democrat* of June 4, 1899 gave the following figures: three nets worked by three crews of 22 men each, an average of 4–5 catches per week in good weather, and an average catch of 80 porpoises. It is not clear, however, to which period of the fishery these data pertain. The single set catch of 170 given by Stick (1958) for November 1, 1886, is the highest known single catch for the fishery.

The figures available for catches by year or season are given in Table 2. There is much con-

TABLE 2. Catch data for Hatteras *Tursiops truncatus* fishery.

Date	Catch data
1797–1860	?irregular operation at moderate level (4–500/season) (Clark 1887a; Stick 1958)
1860–70?	Inactive
1871–?	Fishing resumed at Cape Lookout
1883–84	?840
1884–85	1268 (True 1891)
1885–86	2049 (Stick 1958)
1886–87	?6450 (2293)
1888	?
1889	?2283 (Stevenson 1904a)
1890	?1747 (Stevenson 1904a; Stick 1958)
1890–93	?closed in 1893
1894–1902	Inactive
1903–06	?inactive
1907	70 (data thru 1914 from Townsend 1914b)
1908	591
1909	1550
1910	1278
1911	826
1912	467
1913	400
1914	1073
1915–27	?about 500 per year (Kellogg 1927)
1928	In operation (files U.S. National Museum)
1929	Closed sometime during this year (Kellogg 1940).

TABLE 3. Size and sex distribution of *Tursiops truncatus* in catches (True 1891).

Date	Males	Females	Largest	Smallest
May 14, 1886	20	14	9 ft 10 inches (300 cm)	6 ft 7 inches (201 cm)
May 15, 1886	10	10	9 ft 4 inches (284 cm)	5 ft 4 inches (163 cm)
May 15, 1886	9	8		
May 19, 1886	6	8	9 ft 3 inches (282 cm)	3 ft 7 inches (109 cm)
May 19, 1886	31	35	8 ft 5 inches (257 cm)	5 ft 3 inches (160 cm)
Totals	82	75	9 ft 10 inches (300 cm)	3 ft 7 inches (109 cm)

fusion in the literature regarding these figures, as summarized in the following paragraphs.

G. L. Sparks, in the Philadelphia Evening News, October 25, 1885, stated that they "have captured thus far 2,108, and expect to go at it again on the first of the coming month." This must include the 1884–85 catch of 1268 given by True (November 15, 1884 to May 15, 1885) and either an earlier catch from the 1883–84 season, or a catch from May 15 to October 25, 1885. The former seems more likely, as there is no indication of any summer catches having been made at Hatteras. Thus, there may have been a catch of 840 in 1883–84. With the later figures, it is not clear whether the statistics pertain to the catch season or to a calendar year. The figures for 1880–90 are useful primarily as a general indication of the magnitude of the fishery. While it is not possible to tell which time period the 1907–14 figures pertain to, they are all from the same source and are thus internally consistent.

A letter from F. C. Zimmerman to F. W. True indicated that the weather and leather prices were bad in 1888–89, the latter perhaps contributing to the closure of the fishery in 1893.

There are several published catch figures that appear to be erroneous or to have no basis. Stevenson (1904b) cites a catch of "about 20,000" in 1887. It is difficult to see where he derives this figure (Mitchell 1975, p. 85), as in an earlier paper (Stevenson 1904a) he gives a catch of 6450 for the same year. Tomilin (1957) cites a catch of 12,000 for 1884–85. This is clearly a misinterpretation of his source (Norman and Fraser 1937; not Fraser 1937 as cited by Tomilin), which gave a catch of 1200 for that period.

School Composition

Size and sex distribution of several catches (Table 3) for the month of May, 1886, were given by True (1891). These figures indicate a nearly even distribution of sexes and a wide size range. True (1891) noted, however, that these animals may have represented heterogeneous groups on the southern end of the northward migration. According to information he received from the fishermen, the groups taken early in the season were more homogeneous, some consisting almost entirely of old males, some almost entirely of young males, etc. Townsend (1914b) examined a catch of 51 animals on November 12, 1913, consisting of 34 females and 17 males. He also noted that the groups were more mixed in the spring and more homogeneous in the fall, but it is not clear whether this was an independent observation or derived from True's report.

Reproduction, Fetuses

Information received from the fishermen at the Hatteras fishery indicated that fetuses were generally small in September, increasing in size as the season progressed (True 1891). The length figures available are as follows (figures in parentheses have been converted from English to metric):

mid-Aug. 1884	12 cm	True (1885a) (Cape May)
Nov. 12, 1913	(38 cm), (32 cm)	Townsend (1914b)
Apr. 30, 1914	nearly (122 cm)	" "
Apr. 30, 1914	Fetuses less than (46 cm)	" "
May 1886	fetus skulls 240, 163 mm	True (1891)

True (1891) noted considerable variation in both the size of the fetal skulls that he examined and in the lengths of nursing or freshly weaned animals, from which he concluded that there was an extended breeding season. This can be seen in the figures for November 12, 1913 and May 1886 given above. The disparity in lengths reported by Townsend for April 30, 1914, however, might indicate two separate peaks of breeding activity. Townsend (1914b) observed captive animals from Hatteras mating in January and again in March and April. Ridgway (1972) also provided evidence suggesting two breeding peaks in *Tursiops truncatus*.

Lactation

On May 19, 1886, True (1891) examined a

catch of porpoises at Hatteras containing 35 females. Of these he found nine to be lactating, but it is not clear how many were adults or whether all of the adult females were examined. Townsend (1914b) examined a catch at Hatteras on November 12, 1913, consisting of 34 females and 17 males, and noted that: "All of the females examined were in milk, and the females killed were not only in milk but also contained young."

During this visit to Hatteras, five adult and five young animals were taken alive for the New York Aquarium, accounting for the differentiation between animals examined and animals killed. If we assume that equal numbers of the sexes were taken alive, then about 29 females were killed. However, some of these were not adult, making it impossible to arrive at the actual number of lactating and pregnant females, though it was probably on the order of 15.

True (1885a) examined two adult females taken in the Cape May fishery and found one of them lactating and the other with a 12-cm fetus.

Food Habits

There are very few data available on the food habits of the Hatteras *Tursiops*. Townsend (1914b) was told by fishermen that they fed primarily on squeteague or weakfish. True (1885a) found common gunnard (*Prionotus carolinus*) in the stomachs of both of the adult females that he examined at the Cape May fishery.

Economic Basis

Utilization of the catch in the early years of the fishery (1810–60) has not been documented, but presumably blubber or body oil was the chief product. This may have been consumed locally or sold along with oil from the sporadic shore fishery for right whales. The body oil brought the same price as whale oil in the later phases of the fishery ($0.35–0.40/gal. True 1885e; Stevenson 1904a). True (1891) gave the average oil yield in the winter as 6–8 gal/porpoise, dropping to 3 or 4 gal/porpoise late in the spring. Stevenson (1904a), however, gave the following yields: 10,460 gal from 6,450 porpoise, 3897 gal from 2283 porpoise, and 2746 gal from 1747 porpoise. These figures are from the peak of the fishery, 1887–90, and are much lower yields than those given by True (amounting to an average of less than 2 gal/porpoise). At this later date, however, the hides were being utilized for leather and much of the oil may have been lost in their processing. The highest oil yield given is 24 gal from a 12-ft animal (True 1891). This seems excessive, as none of the documented animals were over 10 ft. The offshore populations of *Tursiops* in the western North Atlantic are larger, as are the animals found along the coast of Europe. This individual may have been one of these, or may have been some other species, such as a young ziphiid.

In the early 1800s it was discovered that porpoise jaw oil was an excellent lubricant. Shortly thereafter pilot whale melon oil was found to possess the same qualities and these oils began to replace olive oil, which had been used for watches and fine instruments. The demand for these oils remained high until recently when they were largely replaced by synthetic oils. Clark (1887a) gave a range of $5–15/gal for these oils, while Townsend (1914b) gave a price of $20/gal. These are probably the prices for the raw oil from the fishermen, and the price of $60/gal given by Sparks (1885b) was perhaps the price of the finished product on the retail market. Sparks (1885b) gave the average jaw oil yield as 4 oz per porpoise, although in my experience it might be closer to double that amount.

During the peak of the Hatteras fishery, hides for leather were one of the principal products. According to Stevenson (1904b) the suppleness and durability of the leather made it particularly desirable for shoes. It also possessed the property of swelling when wet, allowing very little water to penetrate the shoe. The same author gave the value of a green hide as about $2 per side (there being two "sides" taken from each porpoise), and a tanned hide as $10–12 per side.

The remains of the carcasses were sometimes processed as fertilizer. The financial prospectus of the Porpoise Fishing Co., of Cape May, New Jersey, 1884, gave an average value of $2.50 per porpoise for this product. The firm of Cooke and Sparks, who operated the Hatteras fishery during its peak, also attempted to market various forms of porpoise meat for human consumption. In a news article in the Philadelphia Evening News, October 25, 1885, G. L. Sparks stated that the firm had sold 25,000 lb of cured and smoked meat, but did not mention the value. There are vague indications (Sparks 1885a) that this marketing effort was unsuccessful, and there was no mention of it after 1885.

Other Species Taken

There are two mandibles of *Steno bredanensis* in the collection of the Museum of Vertebrate Zoology, University of California at Berkeley (MVZ 23715, 23716), which were collected in 1915 from the Hatteras fishery. This is the only documented instance of a species other than *Tursiops truncatus* being taken in this fishery.

True (1885e) reported a "large series of skulls of *L. perspicillatus* [=*Lagenorhynchus acutus*] was sent to the Museum [United States National Museum] a number of years ago by Drs. Coues and Yarrow, from Fort Macon, which is not very far distant from Hatteras." True suspected that the Hatteras fishery was based on *L. acutus*, and the purpose of his visit to the area in 1884 was to obtain material of that species. Upon examination of the Fort Macon skulls, they proved to actually belong to *Tursiops truncatus*.

As noted earlier, the 12-ft animal reported by True (1891) may not have been a *Tursiops*, but some unidentified species.

Cape May, New Jersey Porpoise Fishery

This fishery was organized in 1884 and apparently operated for 2 yr (Sparks 1885b). The fishery was operated by the firm of Cooke and Sparks (the Porpoise Fishing Co.), using the large Cooke Patent Net. According to Sparks (1885b), the venture failed after the loss of two of the steamers used to haul the large net. Sparks (1885b) gave a total catch of about 120 porpoise, while True (1884) reported that as of August 1884, they had taken over 200 for the year. Even though the data are poor, they serve to indicate that this was not a major fishery.

Long Island Fishery

In the late 18th century there was an apparently substantial porpoise fishery on the eastern end of Long Island (L'Hommedieu 1794; DeKay 1842). The technique employed was essentially the same as in the Hatteras fishery, with a long net set parallel to the shore, the school being trapped by two smaller nets set off either end. The porpoise were taken both for oil and leather, as at Hatteras.

The species taken is not well described, and hence open to question. It was almost certainly not *Phocoena* as indicated by DeKay. The average oil yield of 6 gal is much too high for *Phocoena*, and is about the same as that obtained from *Tursiops* in the Hatteras fishery. *Tursiops* does not frequent the coast of Long Island in any numbers today, but neither does any other small cetacean. From the manner in which they were taken, it is more likely that the species was *Tursiops truncatus* than the next most likely species, *Lagenorhynchus acutus* or *L. albirostris*, both of which may have been fished elsewhere, but not usually by net.

Unfortunately, no data are given on catch sizes, fishing season, or duration of the fishery; DeKay's (1842) work contains essentially an abstract of L'Hommedieu's (1794) paper which dealt only with fishing technique.

Effect of These Fisheries on the Populations

None of the data for the *Tursiops* fisheries are adequate to allow an evaluation of catch effort trends. In all cases the fisheries were subject to catch variation brought on by weather conditions, and to effort variations as a result of economic factors. The close of the early phase of the Cape Hatteras fishery (1797–1860) was more likely due to socioeconomic factors than to a decline in the stock. Likewise, there is some indication that economics played a role in the close of the fishery in 1893, though the high catches in this period may well have reduced the population to the point where fishing became economically difficult.

The extremely high pregnancy and lactation figures given by Townsend (1914b) may indicate a population reacting to relatively heavy pressure. Unfortunately the figures given by True (1891) are not complete enough to allow a comparison between early and late phases of fishing. While the high catches in the period 1883–93 may have had a considerable effect on the population at that time, it was clearly able to recover to the point where it supported another active fishery 14 yr later.

The Cape May fishery, which may have been exploiting the northern end of the same population as the Hatteras fishery, was probably small and short-lived enough to have a negligible effect on the population.

Unfortunately there are so few data for the Long Island fishery that even speculation is difficult. If this fishery were in fact based on *Tursiops truncatus*, it may have contributed significantly to the lack of that species along those shores today.

Mitchell (1975, p. 85) made a cumulative catch estimate of population size of the stock fished off Hatteras, estimating "a minimum population of 13,748, or approximately 17,000 by assuming an (unknown) catch of 3,000 for 1888."

Current Factors Affecting this Stock

Although there are no precise data, the distribution of the *Tursiops* population formerly fished at Hatteras has probably been affected by such factors as pollution and ship traffic. The latter may be particularly important, as the *Tursiops* appear to habitually follow fishing boats in the area. Shrimp trawling is quite heavy in the winter, possibly resulting in a disruption of the migration stream.

There is still a small, shore-based net fishery for

food fish in the Hatteras area, using much the same techniques as were used in the porpoise fishery. A few *Tursiops* may be killed incidental to this fishery, probably on the order of a few tens of animals or less per year.

In some areas the porpoises are considered a nuisance by fishermen and are occasionally shot (Caldwell and Caldwell 1972). It would be very difficult to estimate the mortality from this cause, but it is probably less than a hundred per year.

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Investigation of Small Whale Hunting in Northern Norway, 1964[1]

DON CHARLES FOOTE[2]

FOOTE, D. C. 1975. Investigation of small whale hunting in northern Norway, 1964. J. Fish. Res. Board Can. 32: 1163–1189.

The author made a field trip to northern Norway in June to September of 1964 to study the techniques and economics of small whale catching. The industry taking small whales exists as a subsidiary to primary producing industries based on fishing or large-scale whale oil production. It takes mainly the minke (*Balaenoptera acutorostrata*) and northern bottlenose (*Hyperoodon ampullatus*) whales and other smaller species. The small whale catcher vessel and its equipment is described in detail with specifications given, and an estimate is made of the costs of purchasing and maintaining boat and gear. Good catch and economic statistics are available on the hunt, but not on the packer, wholesaler, and retailer; nor on the separation of those boats used as whalers from March to September from others in the fishing fleet. Whale hunting and food product preparation is described. An economic assessment of costs is made, from hunting through packing, wholesaling and transport, and final retaining of the food products. The purchase, packing, and wholesale of whale meat products operates through a system based on fish production.

FOOTE, D. C. 1975. Investigation of small whale hunting in northern Norway, 1964. J. Fish. Res. Board Can. 32: 1163–1189.

L'auteur participa à une campagne au nord de la Norvège, de juin à septembre 1964, dans le but d'étudier l'économique et les techniques de capture des petites baleines. La capture des petites baleines est subsidiaire d'une industrie de production primaire fondée sur la pêche ou sur la production sur une haute échelle d'huile de baleine. L'industrie capture surtout le petit rorqual (*Balaenoptera acutorostrata*) et l'hypéroodon du nords (*Hyperoodon ampullatus*), ainsi que d'autres espèces plus petites. L'auteur décrit en détail, avec devis, le chasseur de faible tonnage et son équipement, et donne un estimé des coûts d'achat et d'entretien du bateau et des engins de capture. Il existe de bonnes statistiques des prises et de l'économique de la chasse, mais non de l'emballage, de la vente en gros et de la vente au détail; les statistiques ne font pas non plus la distinction entre les bateaux utilisés comme baleiniers de mars à septembre et le reste de la flotille de pêche. L'auteur décrit la chasse elle-même et la préparation des produits comestibles. Il évalue les coûts depuis la chasse jusqu'à la vente au détail, en passant par l'emballage, la vente en gros et le transport. L'achat, l'emballage et la vente en gros des produits de la chair de baleine se font suivant un système fondé sur la production de poisson.

Accepted March 14, 1975 Accepté le 14 mars 1975

THE following report resulted from research on the question of small whale hunting in northern Norway, begun in June 1964. At that time, a bibliographical search of whaling literature was made at the Scott Polar Research Institute, Cambridge, England, in an effort to establish the status of current research being conducted outside of Norway on the problem of Norwegian small

[1]Circulated at the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974; prepared for the Fisheries Research Board of Canada, Arctic Biological Station, December 31, 1964 (see Editor's note).

[2]*Editor's note*: Don Charles Foote was killed in an automobile accident in Alaska on March 1, 1969. At that time he was Associate Professor of Human Geography at the University of Alaska. He prepared this paper under contract for the Fisheries Research Board of Canada, July 15, 1964 and carried out the field and library work June to December of that year.

In editing it for publication, I have modified Foote's wording as little as possible. Mr I. Christensen also reviewed it, and some changes he suggested have been entered and are designated by his initials (IC). We agreed that Foote may have misunderstood his informants regarding some aspects of the economics of processing in the sections following "Whale hunting costs." I have omitted only a few of the photographs that he shot during his study; most are here reproduced in the order of the original manuscript. It must be emphasized that Foote's study was carried out in the last half of 1964, that it relates to conditions mainly in 1960–63 and 1964, and that it is thus an historical document. I have not changed the tense he used, and this must be kept in mind on reading and interpreting the manuscript, as some conditions may have changed appreciably since then.

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whale hunting. In mid-June, contact was made in Oslo with the Institute of Marine Biology and the Institute of Whale Research, University of Oslo, and the Game Department of the Norwegian government. A research scientist of the Norwegian Polar Institute interested in small whales was also interviewed.

As a result of information obtained during these interviews, I decided to conduct further field studies in the Vestfjorden region of Nordland, northern Norway. Correspondence with marine biologists in northern Norway was started in early July 1964, and during the third week of July a study trip was taken to Sandefjord, southern Norway. Here, representatives of the International Whaling Statistics Office were interviewed. The library holdings of the Sandefjord Whaling Museum were checked for literature pertinent to the small whaling industry.[3]

By late July arrangements were confirmed with the Norwegian government which permitted me to join the whale hunting inspection boat *Utvaer*, stationed in the Svolvaer–Skrova area of northern Norway. In mid-August I flew from Oslo to Svolvaer (Fig. 1) where immediate contact was made with *Utvaer*. Because of the preliminary correspondence, ready contact was made with whale hunters based at Skrova. It was agreed at this time that I could travel on board the whale catcher *Havbøen*.

Whale hunting began 12 h after my arrival in Skrova. I was fortunate to observe a number of boats in operation throughout the length of Vestfjorden. *Havbøen* chased several whales and successfully captured one. This allowed me to investigate all important aspects of the hunt, butchering, and preparation of the meat and blubber. Opportunity was also found to undertake a number of personal interviews with whaling captains operating in the Vestfjorden region. In Skrova and Svolvaer, interviews were made with the buyers and packers of whale products, the district veterinarian responsible for the meat inspection, and the government whale inspector responsible for the enforcement of whaling regulations.

The preparation of whale meat products was observed in the Svolvaer–Skrova area. However, in order to investigate the use of whale blubber, and to gain further information on north Norwegian whale hunting, it was necessary to travel to Tromsø. Here, studies included contacts with several commercial firms engaged in the processing of whale meat and oil, the Norwegian whale hunters' sales organization, and marine biologists at the Tromsø Museum.

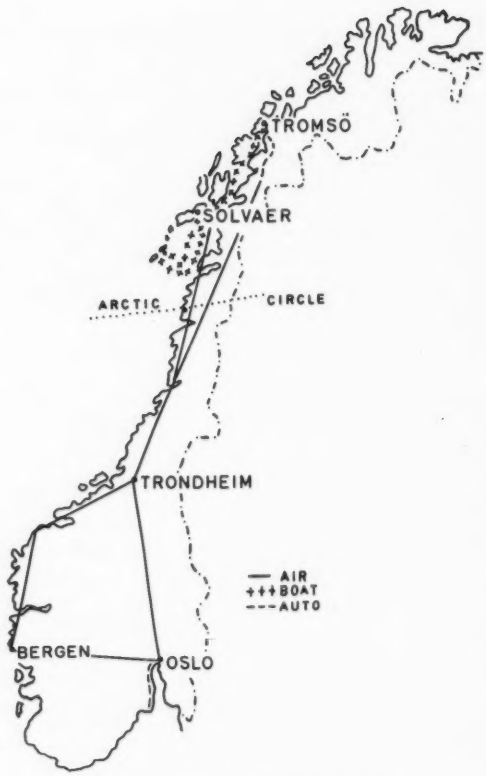

FIG. 1. Field trip by D.C.F. in 1964.

To investigate further the economics of small whale hunting and to gain additional knowledge of marine biological studies, it was necessary to visit Trondheim and Bergen. At the latter place interviews were carried out with representatives of the Norwegian Fisheries Directorate, the Vestlandske Boat Builders Association, and a Norwegian whale oil refining company.

Field travels in northern and western Norway (Fig. 1) were completed during the first week of September. In Oslo, contact was renewed with the Institute of Marine Biology, Institute of Whale Research and the Game Office and Norwegian Polar Institute. A number of interviews were also conducted with businessmen concerned with the wholesale and retail sale of whale meat products and representatives of Norwegian industry who supply the basic equipment used in the small whale hunting industry. Continued library studies were made at the University of Oslo. Active field

[3]The reference section contains the sources used by Foote, but not all are cited directly in the text. (EDM)

studies in Norway were concluded on September 15, 1964.

It should be clearly understood that this report is based on a relatively brief investigation of the north Norwegian small whale hunting industry. For this reason it can attempt to do no more than outline the essential parts of the industry and draw generalized conclusions.

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Historical Background

Development of Norwegian Small Whale Hunting

The killing of whales along the Norwegian coast dates far back into antiquity. In early times the small cetacean species such as the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) and little piked or minke whale (*Balaenoptera acutorostrata*) were captured with strong nets or poisoned arrows. The latter method was in use as recently as 1890 (Jonsgaard 1955, p. 699). After this date little piked whales were usually killed with high-powered rifles.

About the turn of the century, Norwegians began to hunt northern bottlenose whales (*Hyperoodon ampullatus*) as an adjunct to seal hunting near East Greenland.[4] Eventually the hunting of these whales, in the region between the Faeroe Islands, Iceland, and Spitsbergen, became a separate industry. This phase of Norwegian whaling declined after the First World War and stopped completely about 1930.

In addition to the hunting of bottlenose whales, Norwegians have taken beluga or white whales (*Delphinapterus leucas*) around Spitsbergen sporadically for almost a century (Lønø and Øynes 1961, p. 267).

Modern Norwegian small whale hunting began in the 1920s along the Møre coast of westcentral Norway. Here hunters had gained valuable experience while killing the basking shark (*Cetorhinus maximus*) and the bottlenose whale. In time, however, these hunters began to exploit the little piked or minke whale because the species was relatively abundant in Norwegian waters, and it produced both meat and oil which could be readily marketed.

By the late 1930s the hunting of small whales, especially the little piked whale, had spread from the Møre region of Norway northward to the Lofoten Islands and Troms county. An important center of north Norwegian whaling was Vestfjorden, south of the Lofoten Islands. Here many of the catcher boats operated from the ports of Skrova and Svolvaer.

Whaling was restricted but not abolished during the Second World War. In the postwar decades the industry again expanded, but this time it included an increasing use of offshore waters, especially the Barents and Norwegian seas. Today (1964) Norwegian small whale hunting extends from the region north of Scotland to Spitsbergen and the Barents Sea to the east, and to Iceland in the west. Nevertheless, Vestfjorden remains the single most important small whale hunting area in northern Norway.

Norwegian Small Whale Hunting, 1962 and 1963

In 1962, 1963, and 1964 the number of catcher boats licensed to hunt small whales and registered in the counties listed are as given in Table 1.

[4]The fishery for bottlenose whales peaked in the 1890s — see *Report*, Mitchell 1975 (cited in *Report*) and Christensen (this volume). (EDM)

TABLE 1. Number of catchers licensed to hunt small whales and registered in the Norwegian counties listed.

County	Number of licensed boats		
	1962	1963	1964
Østfold	5	5	5
Vestlandet	18	17	16
Møre and Romsdal	42	41	36
Trøndelag	12	10	9
Nordland	92	89	85
Troms	11	10	9
Finnmark	4	4	4
Total	184	176	164

TABLE 2. Production of meat, blubber, and bone from entire Norwegian small whaling industry, 1962–63.

Year	Meat (*Kg*)	Blubber (*Kg*)	Bone (*Kg*)	Value in kroner
1962	5,151,385	2,272,808	4,092	9,450,876.00
1963	5,056,208	2,171,107	45,514	9,234,887.00

The tendency for fewer whalers to participate in the hunt each year has been evident since 1949 when a maximum of 384 licenses were issued (Holm 1962, p. 10). On the other hand, this steady decrease in the number of licensed whalers has not resulted in a corresponding decrease in the total number of whales killed. Since 1949, the annual take of little piked whales has averaged from about 3000 to 3500. This kill has been made possible by improved methods of processing the animals on board ship and the increased exploitation of offshore waters.

In 1962 and 1963 the production of meat, blubber, and bone from the entire Norwegian small whaling industry was as listed in Table 2.

At the moment the Norwegian small whale hunting grounds are divided into 12 distinct districts. They are:

I	Skagerak
II	Vestlandet
III	Møre and Trøndelag
IV	Helgeland
V	Vestfjorden
VI	Vesteraalen and Troms
VII	West-Finnmark
VIII	East-Finnmark
IX	Barents Sea — The Eastern Field
X	Barents Sea — The Northeastern Field and Spitsbergen
XI	Bjønøya
XII	Shetland, Island, and Jan Mayen

Hunting regulations and, at least since 1964, prices for whale meat and blubber, are determined by the particular hunting region in question. For the past few years, the catch of whales from districts IX through XII has accounted for more than 50% of the total number of whales killed by the entire industry. Of the coastal hunting districts the Vestfjorden area, district V accounts for about 10–20% of the total Norwegian kill. It has been the best coastal small whaling ground in the nation. For this reason it is appropriate to study the Vestfjorden region in some detail.

Small Whale Hunting: Whale Catcher Equipment

BOATS

Most of the boats engaged in the present Norwegian small whale hunting industry are of wooden construction with an overall length between 40 and 80 ft. The 1963 whaling fleet was composed of vessels with lengths as given in Table 3.

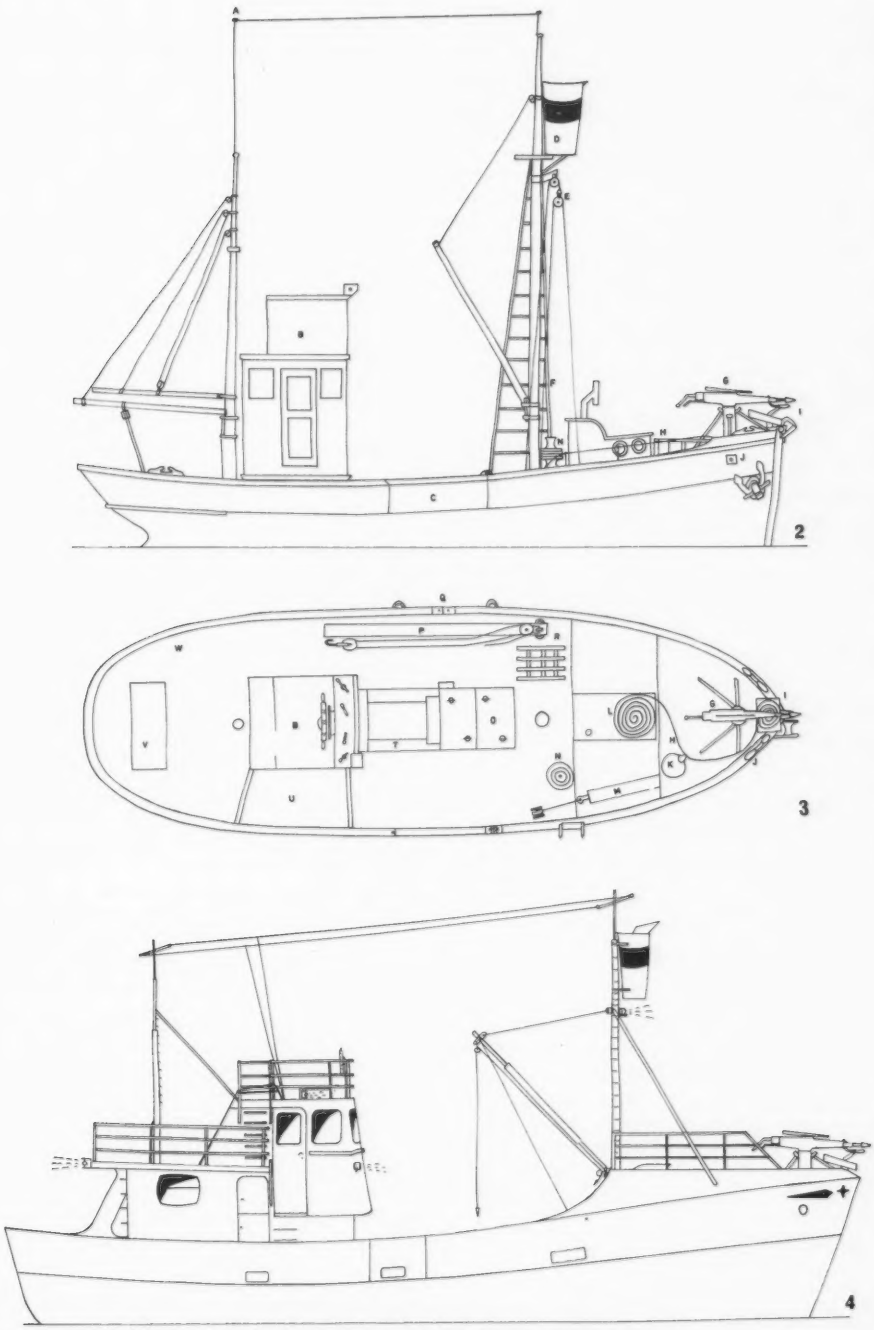
The larger boats, those over 50–60 ft, can be used in hunting the offshore waters from Jan Mayen to Spitsbergen and the Barents Sea. In contrast, the activity of smaller, wooden boats is almost always confined to coastal regions (Fig. 5). Some of the large craft are of steel hull construction.

A typical whale catcher used in the Skrova area of northern Norway is the common fishing boat adapted to whale hunting (Fig. 2–3). In this region, the wide, flared stern is preferred because it provides additional deck space; an important feature when the vessel is occupied with net fishing, but of no apparent advantage to whaling. Boats used in small whale hunting in south western Norway have the customary, rounded, cruiser stern.

While individual boats vary in length from 30 to over 110 ft, Norwegian hunters and ship builders agree that a minimum length of 35 ft

TABLE 3. Vessel length in 1963 whaling fleet (source: Anon 1963c, 1).

Overall length (*ft*)	Number of boats
30–39	10
40–49	47
50–59	42
60–69	37
70–79	28
80–89	7
90–99	1
100–109	3
110 and over	1
Total	176



FIGURES 2–4. Small whale catchers.

FIG. 2,3. Side and top views, wooden hull whale catcher; FIG. 4. Side view, steel hull whale catcher.

is necessary to safely accommodate the modern hunting equipment now installed on all catcher ships. The minimum length is determined primarily by the 50-mm whaling cannon that requires a solid platform for the gun mount, and a ship's hull strong and heavy enough to remain unaffected by the weapon's weight and recoil. Cannons of a smaller caliber, 37 or 20 mm, could be installed on boats less than 35 ft long.

Crew accommodations and cargo capacity vary with the size of a whale catcher. Larger boats are necessary for hunting the offshore grounds because the vessels must be able to weather severe storms at sea, their storage area must be great enough to take the meat and blubber from a dozen or so whales, and the crew's quarters should be sufficient to house at least eight men. In contrast, boats working the inshore, coastal regions seldom, if ever, continue their hunt in windy weather. They put into a local harbor to wait for calm seas. Because the inshore kill of whales at any one time is usually from one to three animals, the meat and blubber can be stored conveniently on the boat's deck. A spacious covered cargo hold is therefore superfluous. Also, a large crew is not necessary on a coastal hunting boat because the vessel operates in the immediate vicinity of shore facilities, and often near the hunters' hometown. For these reasons, a small boat is quite suitable for the coastal hunt. The average length of boats used in the Vestfjorden region is 50 ft.

The Norwegian whale catcher is normally a clean, comfortable vessel. The forecastle is outfitted with individual bunks, table, storage cabinets, and a "fisherman's stove" — an oil burning heater. For cooking purposes many boats carry an additional stove, using propane gas, in a small galley aft of the wheel house.

The specifications (Table 4) illustrate the differences between typical small coastal catcher boats used in northern Norway.

Catcher boats used in the hunt for small whales in northern Norway are sometimes constructed locally. More often, however, the vessels are built in southwestern Norway and shipped north. Construction costs for a 35 ft wooden boat, suitable for small whale hunting but without the added equipment of engine, cannon, and hunting gear have been estimated by the West Norway Boat Builders Association of Bergen as follows:

EQUIPMENT INSTALLED

Length	35 ft
Beam	11 ft 6 inches
Draft	5 ft 9 inches
Weight	13 br. ton
Crew	5 men
Planking of Norwegian pine	
Hydraulic steering engine	
Pyro oilfired cabin stove for heating and cooking	
Line windlass	
Bermudian rig on main sail, gaff rig on aft mast	
Desk pump	
Six inch compass	
Top, side, and stern lanterns	
Wheelhouse roof lights for deck and other lighting	
Cabin, engine, and wheelhouse lights	
Double chainroller on bow	
One anchor and two shackles, chain	
Two mooring ropes, 30 fath each	
Engine room oil tanks, about 100 liters	
Freshwater storage tanks, about 200 liters	
Small water tank for galley and/or engine room	
Ballast welded in between frames and hold	
Price for boat delivered to west Norway[5]	73,000 kr.

EXTRAS

Hydraulic propeller outfit (sterngear)	7,500 kr.
Mechanical propeller outfit (sterngear)	4,500 kr.

Exact depreciation costs on a vessel of this size and design are difficult to estimate. If a wooden boat does not develop dry rot in its first years of use, and it is engaged in coastal waters similar to those of northern Norway, hunters and builders alike assume a 20-yr working life for the vessel. With extensive rebuilding the boat can be made serviceable for an additional 20 yr. A small, steel hulled boat might be operational for about 40 yr before complete reconditioning is necessary. Where the boat will navigate in sea ice a strengthened hull normally assures a working lifetime similar to craft used in ice-free waters.

Estimated building costs for wooden- and steel-hulled boats in Norway suitable for small whale hunting but without added equipment such as engine and hunting gear, are as in Table 5.[6]

Figured on the basis of a 20-yr working lifetime for wooden boats and 40 yr for steel vessels,

[5]According to information received from the West Norway Shipbuilders Association, Bergen (*in litt.* 1974), today a wooden builder would use laminated frames and pressure-impregnated plankings to avoid the previous problem of rot. Thus, a 20-yr service for a wooden vessel has no relevance today, as a wooden hull would last as long as a steel hull. Today very few boats between 35 and 50 ft are built of wood. The tendency now is towards G.R.P. hulls and concrete hulls. This will automatically reduce the hull maintenance considerably. However, there will be some extra expenses for electronics, which will equal the difference in hull maintenance costs. (IC)

[6]According to information received from the West Norway Shipbuilders Association, Bergen (*in litt.* 1974), today these estimated building costs would be equal for the two materials: (*see opposite*)

TABLE 4. Specifications of small coastal catcher boats in northern Norway.

Length (*ft*)	Beam (*ft*)	Beam (*inches*)	Draft (*ft*)	Draft (*inches*)	Dead wt (*tons*)	No. of Crew	Space in hold (m^3)
35 wood	11	3	5	8	10.7	5	11.4
35 wood	11	6	5	9	13.0	5	10.5
36 steel	11	6	5	8	—	—	—
40 wood	12	9	6	4	13.2	6	17.2
40 wood	12	8	6	4	—	5	19.4
40 steel	12	7	6	1	—	5	—
50 wood	15	0	7	6	—	9	34.3
50 wood	15	2	7	8	—	8	36.3
50 steel	16	0	8	0	—	—	—

the annual depreciation on the above-mentioned boats would be as outlined in Table 6.

ENGINES

Two types of engines are used on the Norwegian catcher boats, the semidiesel and diesel. There appeared to be widespread assent among the whaling captains and boat builders that the diesel engine was superior to the semidiesel, especially with regard to whale hunting. It is easily started and stopped, in contrast to the semidiesel which is kept at idling speed when a boat heaves to during the hunt. Under these circumstances the engine and slowly turning screw emit enough sound to possibly alert or frighten a nearby whale. Furthermore, the diesel weighs less and runs more smoothly with less noise than the semidiesel. Some whalers in northern Norway admitted they would switch to a diesel engine if they were financially able to do so.[7]

There was no unanimous opinion among whaling captains, boat builders, and marine engine manufacturers on the ideal horsepower for a given sized whale catcher. For example, recommended horsepower for a 35 ft catcher ranged from 36 to 57 hp engines and for a 40 ft boat from 40 to 80 hp. On the average, however, the recommended horsepower for engines in various sized whale catchers is as given in Table 7.[8]

The purchase price of diesel and semidiesel engines varies slightly from one manufacturer to another. The Mandals Motorfabrik, Mandal,

TABLE 5. Estimated building costs for wooden and for steel hulled boats without equipment such as engine and hunting gear.

Length (*ft*)	Wooden hull (*kr*)	Steel hull (*kr*)
35	80,000	130,000
40	110,000	150,000
50	150,000	275,000

TABLE 6. Estimated annual depreciation of boats in Table 5 (see text).

Length (*ft*)	Wooden hull (*kr*)	Steel hull (*kr*)
35	4000	3250
40	5500	3750
50	7500	6875

Length	Estimated cost
35 ft	N.kr. 200,000.
40 ft	N.kr. 300,000.
50 ft	N.kr. 450,000.

As regards maintenance of the steel hull, all vessels built today will have shotblasted plates with advanced paintings, thus reducing annual cost. The expenses to shipyard for maintenance work is up 400%. (IC)

[7]According to information received from the West Norway Shipbuilders Association, Bergen (*in litt.* 1974), now only diesels are used. Due to space, fast running diesels are used with a variable pitch propeller, which can rotate without moving the vessels and thus also keep the ice away when the vessel is not moving. (IC)

[8]According to information received from the West Norway Shipbuilders Association, Bergen (*in litt.* 1974), it appears that the horsepower required today compared with 1964 has greatly increased, and there will be no difference in horsepower as regards the material used in building the hull. Generally, present horsepower requirements are:

Length	hp
35 ft	100/150
40 ft	100/150
50 ft	175/200

(IC)

TABLE 7. Recommended horsepower for engines in various whale catchers.

Length (*ft*)	Wooden hull (*hp*)	Steel hull (*hp*)
35	40–60	80
40	45–75	80
50	75–135	147

TABLE 8. Approximate annual depreciation costs for power unit in a 10-yr working life.

Diesel engines (*hp*)	Cost in kroner	
	New installation	Per year
36	21,600	2160
48	29,400	2940
60	32,900	3290

TABLE 9. Estimated cost of catcher boat, fitted with diesel engines.

Length (*ft*)	Cost in kroner	
	Wooden hull	Steel hull
35	102,000	152,000
40	140,000	180,000
50	183,000	308,000

Norway and other companies, supply diesel engines well suited to wooden and steel whale catchers. Representative prices of Mandal engines are as follows:

Marina: diesel engine, 36 hp, type M3	17,100 kr.
Marina: diesel engine, 48 hp, type M4	24,900 kr.
Marina: diesel engine, 60 hp, type M4	28,400 kr.

Fuel consumption of engines of different horsepower varies with the type, diesel or semidiesel, age of the machine, and running speed (rpm). An approximation of the average fuel consumption is as follows:

hp	Fuel consumption (liters per hour)
36	8
40	10
48	12
60	15

Depreciation of the marine engines depends largely upon the maintenance and operating skill of the owner. Whaling captains in the Skrova region agreed that a whale catcher would use two engines after 20 yr of service. Installation costs for a new engine are about 4500 kroner. On the basis of a 10-yr working life the approximate annual costs of depreciation for the power unit would be as in Table 8.

TABLE 10. Estimated annual depreciation of whale catcher, with one change of engine every 10 yr.

Length (*ft*)	Wooden hull (20 yr) (*kr.*)	Steel hull (40 yr) (*kr.*)
35	6,180	4,880
40	8,470	5,970
50	10,795	9,345

TOTAL COSTS — BOAT AND ENGINE

A general estimate of costs for catcher boats, suitable for small whale hunting, fitted with diesel engines and delivered in western Norway shipyards can be calculated from the foregoing information (Table 9).[9]

It can be further calculated from the preceding discussion that the average Norwegian whale catcher, with one change of engines every 10 yr, will depreciate annually as given in Table 10.

ANNUAL REPAIRS AND UPKEEP

The estimates by whaling captains and Norwegian boat builders on the average annual costs for the repairs to a whale catcher and its engine ranged from 5,000 to 10,000 kroner. In general, the costs depend upon the boat and engine types involved, their age, and the quality of service given the equipment. An annual outlay of 6000 kroner for repairs is not unreasonable.

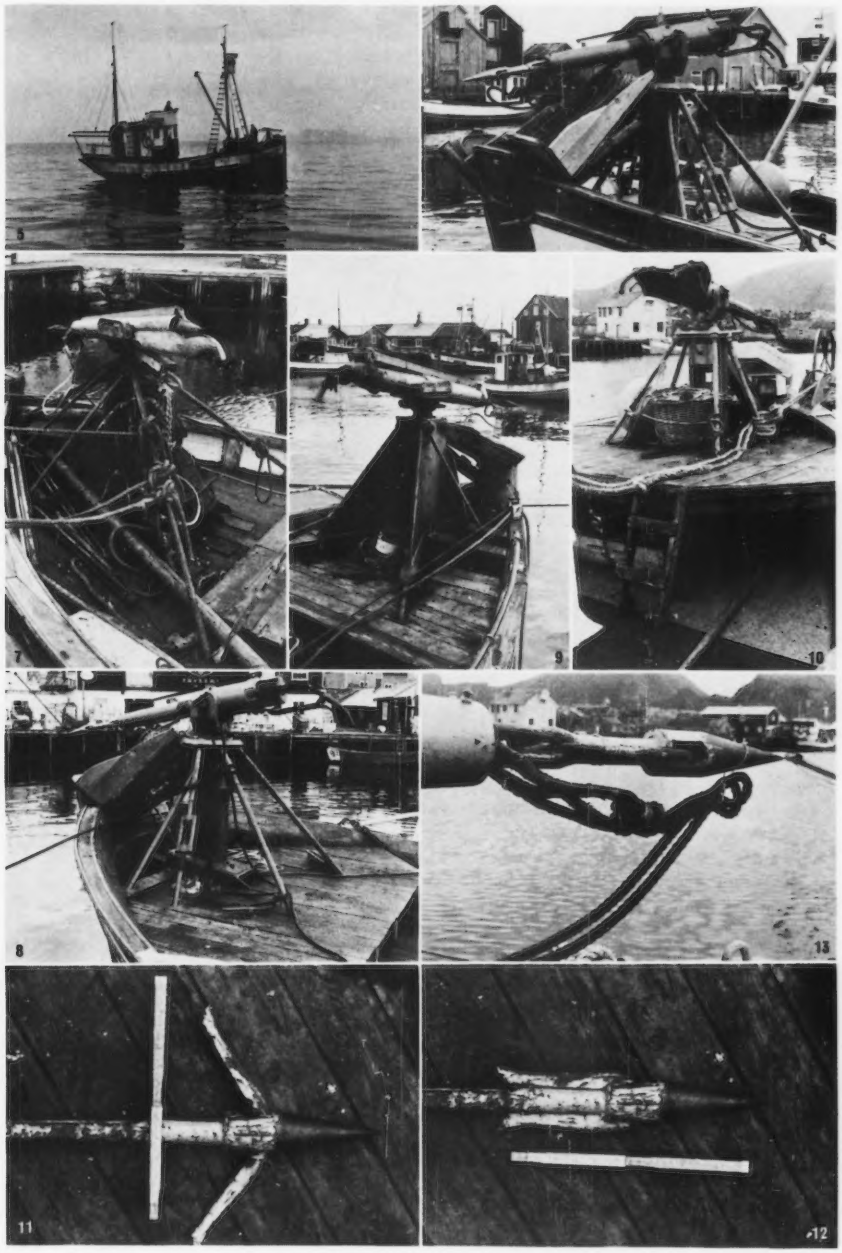
WHALE HUNTING EQUIPMENT

Once the standard Norwegian fishing boat has been constructed and equipped with an appropriate engine, the whaling captain must make special modifications necessary for modern small whale hunting. These include the whaling cannon and its mount, harpoons, lines, floats, crows nest, conning tower, reduction spring, loading door, outrigger, and other minor accessories.

WHALE HARPOON CANNON

Nearly all boats at present engaged in the north Norwegian small whale industry are armed with

[9]According to information received from the West Norway Shipbuilders Association, Bergen (*in litt.* 1974), the total cost for a finished boat with engines, etc., delivered in a West Norwegian shipyard today largely depends on what other equipment she is to put onboard, especially within the electronic range. (IC)



FIGURES 5–13. Whale catcher boat, cannon, and harpoon.

FIG. 5. Whale catcher in Vestfjorden, August 1964; FIG. 6. Kongsberg 50-mm whaling cannon; FIG. 7. Old type whaling cannon; FIG. 8. Cannon mount; FIG. 9. Cannon mount; FIG. 10. Cannon mount, shooting platform; FIG. 11. Whaling harpoon, two claws extended; FIG. 12. Whaling harpoon, two claws closed; FIG. 13. Harpoon seated in whaling cannon;

the Kongsberg 50-mm whaling harpoon gun (Fig. 2–3G, 6). A few vessels still use older weapons of a 37-mm caliber, often made locally from such materials as railway car axles (Fig. 7). Prior to World War II many Norwegian weapon factories manufactured whaling guns of 26-, 37-, 50-, and 90-mm calibers. At present the only commercially built cannons in Norway are 50-, 60-, and 90-mm cannons sold by the Kongsberg Vaapenfabrikk [and a 60-mm cannon manufactured by Henriksen, Tønsberg; (IC)]. In Sweden the Bofors company also construct a 90-mm weapon, but it is too large for small whale hunting. Some large Norwegian boats, designed to hunt small whales in offshore waters, carry a 50- or 60-mm gun on the bow and a 37- or 50-mm cannon on the stern.

There was unanimous agreement among the Skrova whaling captains that the Kongsberg 50- or 60-mm cannon was well suited for the capture of small whales. It is a breach loading weapon capable of propelling a harpoon accurately for about 70 yards. The normal firing charge in the 50-mm cannon is 40 g of black powder packed in a brass shell case.

Costs of the Kongsberg 50-mm whale cannon and associated equipment are as follows:

Equipment	Kroner
50-mm harpoon gun	14,500.00
Brass shell case	28.00
Powder, wadding, caps	7.60/shot

Barring an unusual accident, depreciation on the whaling cannon is negligible. It should easily survive the average 20-yr life of a catcher boat. Figured on the basis of a 20-yr working life, the annual depreciation would be 725.00 kroner. If it is assumed that the cannon requires, on the average, 10 shell cases in 20 yr, and it is fired 20 times each year, then the annual operating costs would be about 166.00 kroner.

Gun Mount

To accommodate the whaling cannon and to assure its safe, successful and sustained use, the weapon must be securely mounted. This fact was recognized quite early in the history of Norwegian small whale hunting when poorly mounted guns tore loose or were considered so dangerous that gunners hesitated to use them without a test firing (Jonsgaard 1954, p. 58). Moreover, a gun not firmly mounted will fire inaccurately.

Except for the vertical stand, fork and swivel, the Kongsberg cannon is not delivered from the factory with a standard mount. This must be installed on the whale catcher by a competent shipwright. For this reason seldom do any two cannon mounts appear to be identical (Fig. 8–9). Nevertheless, most mounts incorporate the same principle of diagonal, adjustable braces securely fastened to the boat's hull. The adjustable braces, which sometimes run to metal plates outside the hull, enable the mount to be periodically tightened. This is especially necessary when the cannon is fired at an unusual angle toward the stern, causing the weapon's recoil to be concentrated on a single brace.

A wooden platform is usually built on top of the cannon mount and supports (Fig. 2–3H, 8, 10). This allows the gunner to move freely on a level surface rather than the sloping forward deck and it effectively covers the metal braces which would make any activity near the bow awkward if not dangerous.

The cost of construction and installation of a satisfactory gun mount varies from one ship building firm to another. Regardless, it would seem that 4000 to 5000 kroner is a reasonable estimate for the cost of the gun mount and associated equipment. The annual depreciation on this investment, for the normal 20 yr life-time of a wooden hulled catcher boat, would be about 225.00 kroner. For a steel boat the cost would be about 110.00 kroner.

Harpoons

Two basic types of harpoons are used in the 50-mm cannon. These are the two-claw and four-claw harpoons. The overall distance between the extended claws, as governed by Norwegian law, is at least 15 inches (38 cm) in the case of two-claw harpoons and at least 12 inches (31 cm) with four-claw weapons (Fig. 11, 12). With both types the harpoon shank and claws must have a minimum tensile strength of over 1500 kg (3000 lb). The usual harpoon is about 144 cm long and composed of a solid butt, a split opening shank, claws, and harpoon head.

The Norwegian government requires that a whale catcher carry at least seven harpoons. Most whalers carry more than this number. Because several small firms in Norway manufacture harpoons, there is constant debate about the best make of weapon. Some gunners prefer harpoons fitted with interlocking claws, and a shank cut from a single metal bar. It was the opinion of a few hunters that harpoons constructed with an oval-shaped shank were stronger than those with

flat sides. All the various types of harpoons presently in use appear to be amply suited to the capture of small whales.

A harpoon fired from the 50-mm cannon normally passes completely through a small whale. This means that the weapon's shank and claws receive a minimum amount of strain when a wounded animal runs before the boat or a dead, sunken whale is hauled to the surface. Nevertheless, harpoons are lost or damaged. Should the weapon strike the whale's backbone, the weapon can be bent or the line can be cut by bone fragments. When a harpoon does not completely penetrate a whale's body it can be badly bent by the subsequent gyrations of the injured animal. In these cases the harpoon must be carefully straightened in order that it carry true in subsequent firings. The repair of a bent or twisted shank is not considered a difficult or expensive job.

The costs of harpoons vary from one manufacturer to another but, in general, a two-claw type costs about 175.00 kroner and the four claw about 200.00 kroner. Accurate figures on the average number of harpoons lost or irreparably damaged in a season's hunt were not available because of the high degree of variation from one boat to another and from one season to the next. It would seem reasonable to suppose that a whale catcher would purchase 15 harpoons in the course of 20 yr of hunting. This would be an overall investment of about 3000.00 kroner, which would depreciate at the rate of 150.00 kroner per year.

Although the Kongsberg 50-mm cannon can be fitted with a grenade-carrying harpoon, the Norwegian small whale hunters do not use this added killing device. It is not necessary. On the other hand, the harpoon grenade would prove useful, should the 50-mm gun be considered for the hunting of large whale species. The explosive charge is housed in the detachable harpoon point and detonated by a primer cap and fuse. Cost of the primer and fuse assembly and grenade are quoted by the Kongsberg Vaapenfabrikk as 15.50 kroner.

To prepare the harpoon for use, a wire cable leader about 30 cm long is made from a length of cable spliced together to form a circle. This is then twisted once into a figure eight and wrapped in heavy hemp cord (Fig. 13). The leader is inserted into the open slot running the length of the harpoon shank. The main forerunner, the harpoon line, is attached to the leader. Before the harpoon is loaded into the cannon, many gunners stuff a handful of wadding, or ordinary engineroom batting, into the slot at the harpoon's butt end. This reduces the possibility of a leader being cut upon firing by the initial thrust of the harpoon. Once the harpoon is seated in the cannon the claws are secured with a light string which breaks under the slightest strain (Fig. 13).

Harpoon Lines

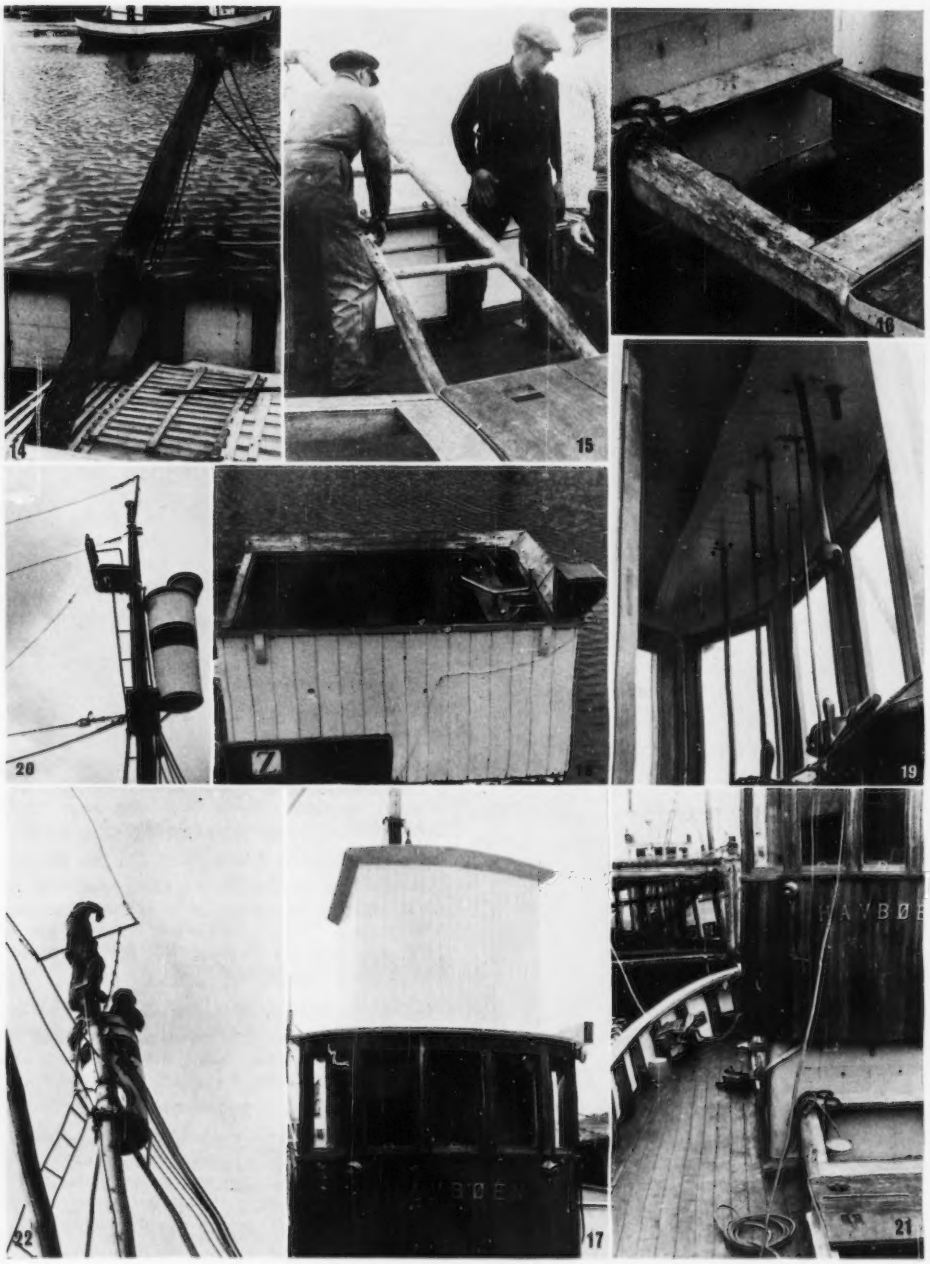
Under Norwegian law each whale catcher is required to carry at least three forerunner lines, each not less than 45 fath long and each with a tensile strength of 1500 kg or greater. In addition to the forerunners the whaler must carry a main line not less than 300 fath long and a second line, used in case of a second shot at a wounded whale, not less than 50 fath long. These two lines must also have a minimum tensile strength of 1500 kg.

The whale catchers in the Skrova area coiled the forerunner in a line tub under or beside the cannon's muzzle (Fig. 2–3I, 6). It can be assumed that today all the whalers use nylon forerunners because of their great strength, elasticity, and relatively long working life of up to 6 or 7 yr. Normally the forerunner is a ½-inch line. The main reserve line has a larger diameter. Some boats were equipped with steel wire for the main line. Several gunners agreed that the best combination was a nylon forerunner connected to a steel wire main line. Other hunters experimented with synthetic fiber lines which, although not as strong as nylon, did have the desired property of good buoyancy.

Because various boats use different combinations of lines, it is difficult to generalize on the average operating costs. Probably each boat has about 2000 kroner invested in forerunner and main lines. Given a 6 to 7-yr life for these lines the total cost over a 20 yr period would be about 6000 kroner or about 300 kroner per year.

Steel Accumulator Spring

In the early days of the Norwegian small whale industry, a number of whales were lost when harpoon lines parted under sudden stress, caused by a wounded animal's quick movement or the lurch of the boat in rough weather. To overcome these mishaps the hunters developed a spring and pulley system which could immediately compensate for these movements of unexpected strain. This equipment, now required by law, normally consists of a steel spring capable of holding at least 1500 kg, and a capacity of moving at least 1.5 m (Fig. 3M). This, in turn, is attached to a pulley near the masthead. Movement of this pulley is translated and doubled by movement of the main line pulley under stress (Fig. 2E).



FIGURES 14–22. Details of catcher boat and equipment.

FIG. 14. Wooden outrigger, single beam type (note meat cooling racks on deck); FIG. 15. Metal outrigger, double beam type; FIG. 16. Deck support for whale butchering; FIG. 17. Conning tower on top of wheelhouse; FIG. 18. Conning tower with engine controls and radio loud speaker; FIG. 19. Control adapter rods running through wheelhouse roof; FIG. 20. Crow's Nest, lookout chair, and side lookout platform; FIG. 21. Compressed air lance; FIG. 22. Lookouts posted at the masthead; Vestfjorden, August 1964.

Introduction of the nylon forerunner and main line have, to a large degree, obviated the need for an accumulator spring system. The natural elastic properties of nylon are enough to compensate for the normal stresses experienced during the hunt. In the case of large whales or rough weather, however, the accumulator is usually attached as a safety measure.

Floats

Unlike the hunters of southwestern Norway, the Vestfjorden whalers usually attach several plastic floats to the harpoon line (Fig. 3K). Norwegian law forbids that a float be fastened to the line at a distance of less than 45 fath from the harpoon. Once an animal is struck, its death struggle often requires that much of the main line be run out. Under these circumstances the whale must also drag from four to six large floats, which hinder the animal's movements and prevent its loss, should it sink. The plastic floats used in the Vestfjorden whale hunt can be used during the fishing season to support nets. Because not all boats use floats and because the gear serves a dual function, it is difficult to assess actual operating costs. One might reasonably suppose costs are about 50.00 kroner per year, the price of a new, medium-sized float.

Outrigger and Loading Door

Until the late 1930s many Norwegian whalers towed their kill to shore, where the animals were pulled out and butchered on land. In place of this time-consuming process, the hunters developed a technique by which the whales were hauled on board the catcher boat. This required larger boats with power deck winches, the construction of a loading door cut into the boat's side, amidships opposite the main hatch (Fig. 2C) and an outrigger (Fig. 3P, 14, 15). The latter is fitted over the boat's rail opposite the loading door. Although there are various types of outriggers made of wood or metal, all employ the same principle. A block is attached to the outrigger's far end, the traveller is run to the boat's deck winch, and the tackle is chained to the small of the whale's tail. To strengthen the outrigger it is the usual practice to connect it to the hull with support cables tightened by turnbuckles.

With this simple loading system a whale can be pulled easily onto the boat. Ordinarily the main hatch and the outrigger provide a suitable butchering platform. On small boats it is sometimes necessary to construct an additional wooden support between the hatch and wheelbase to prevent the dead whale from rolling off the hatch on to the deck (Fig. 3T, 16).

Because this loading equipment differs from one catcher to another, it was not possible to obtain exact cost estimates for materials and construction. The average outlay for loading door, outrigger, hatch supports, block and tackle, and outrigger support cables is probably about 2000 kroner. Annual depreciation for this gear during the life-time of a whale catcher is about 100 kroner.

Conning Tower and Crow's Nest

Originally the Norwegian whalers maneuvered their boats from the main wheelhouse during a hunt. This did not allow the steerman a maximum range of visibility, especially over the bow, the most important area to be observed when closing for the kill. The whalers overcame this problem of restricted vision by construction of a conning tower built on the roof of the wheelhouse (Fig. 2B, 17, 18).

The conning tower is equipped with a steering wheel and engine controls connected to the main wheelhouse by a simple system of adapters run downward through the wheelhouse roof (Fig. 18, 19). Most conning towers are fitted with a loudspeaker connected to the boat's radio telephone.

Early in the days of modern small whaling, the hunters realized they needed a high lookout from which a constant watch could be kept. After experimentation with ladders and wooden platforms fitted to the main mast, the whalers settled on an "ice barrel" or wooden crow's nest (Fig. 2D, 20). Since 1939, Norwegian law has required that all whaling vessels shall have a "strong wooden barrel, attached to the mast, the barrel painted white, but with a black band, 30 cm wide around the middle." This painted barrel makes the catcher easily distinguishable from other small craft. The black band set them off from seal and basking shark hunting vessels which also carry an ice barrel on the main mast.

In addition to the crow's nest, some whale hunters have equipped their boats with small platforms or a chair large enough to accommodate one or two extra lookouts (Fig. 20). The barrel can hold two men. Thus, it is not unusual to see three or four men stationed at the masthead during the early stages of a hunt. To assist the captain in conning the boat a loud speaker, connected to the main wheelhouse radio, is sometimes rigged in the crow's nest.

Costs of the conning tower and its equipment and crow's nest vary greatly from one boat to another. The average expense appears to be about 2500 kroner for the normal 20 yr serviceable life-

time of a catcher. Annual depreciation is about 125 kroner.

Landing, Butchering, and Storage Gear

All north Norwegian catcher boats carry a variety of gear used to land, butcher, and store the dead whale. It is standard practice, regulated by law, for boats to be outfitted with a compressed air lance, landing hook, meat cooling racks, and blubber compartment.

Because the little piked whale sinks when killed, it is common practice to spear the dead animal in the tongue or body with a long, metal lance attached by a rubber hose to an air compressor. Air is injected into the whale through holes in the lance tip (Fig. 21). The average lance is about 300 cm long. The use of engine exhaust gases to inflate the whale is illegal. Only the use of compressors or hand pumps fed by pure air is legal.

When the dead animal is pulled through the loading door and onto the deck hatch, it is usual to attach a large metal hook into the whale's side or back. This hook, firmly hitched to the boat's rail opposite the outrigger, prevents the dead animal from rolling forward onto the deck or toward the outrigger. It also allows the carcass to be stretched out full length under the tension from the outrigger block, thus facilitating the butchering process.

As the fresh meat is removed from the whale it is carefully placed on white painted, clean wooden racks laid out on the deck (Fig. 3R, 14). These racks protect the meat from unnecessary contamination and allow air to circulate on all sides, thus cooling the meat. Normally one area of the deck is selected for the storage of blubber. This can be behind or beside the wheelhouse. Some whalers rig special boards between the wheelhouse and boat's side to contain the blubber strips (Fig. 3U).

The total costs for the equipment used in landing, butchering, and storing the whale probably amount to about 1000 kroner or about 50 kroner per year over a 20-yr period.

Harpoon Rifle

Many of the Vestfjorden whalers apparently owned Kongsberg harpoon rifles and at least one high-powered rifle. This equipment probably costs about 1400 kroner and depreciates at a rate of 70 kroner per year for 20 yr.

Radio Telephone

Modern radio telephones are now standard equipment on most, if not all, Norwegian whale catchers. These are essential for safety reasons and because they enable hunters to work as a team, one boat alerting another to the location of a whale. The radio is also used to establish contact with the land-based meat packer.

The sale price of radio equipment differs from one manufacturer to another. Nevertheless, a reasonable estimated cost would seem to be about 3000 kroner spent every 10 yr. This would amount to about 300 kroner per year.

Table 11. Approximate annual equipment costs for wooden boats, calculated on a 20-yr basis.

Equipment	Total costs in kroner for 110-day season		
	35-ft boat	40-ft boat	50-ft boat
Boat and engine	1870	2550	3245
Repairs	1800	1800	1800
Cannon (50 mm)	725	725	725
Cannon mount	225	225	225
Harpoons	150	150	150
Ammunition	166	166	166
Lines	300	300	300
Floats	15	15	15
Outrigger and door	100	100	100
Conning tower and crow's nest	125	125	125
Air lance, hooks, etc.	50	50	50
Harpoon rifle	20	20	20
Radio	90	90	90
Total (avg. annual costs: 6321 kr):	5636	6316	7011

Summary of Equipment Costs

To adapt an ordinary fishing boat to small whale hunting, a significant amount of equipment and added construction is necessary. Because the Norwegian whale hunters use their boats for fishing as well as whaling, some of these costs must be measured against the year round use of the equipment. This is true for the boat, engine, radio, and annual repairs. On the other hand, costs associated with whaling equipment only must be measured against the length of the average whaling season. Based on 1962 and 1963 statistics, it seems reasonable to assume the average season in the Vestfjorden region is about 110 days long. Therefore, approximate annual equipment costs, calculated on a 20 yr basis, for wooden boats 35, 40, and 50 ft in length would be as given in Table 11.

Whale Hunting and Food Product Preparation

The Whale Hunt and Kill

The two most important controls on small whale hunting in Norway are government regulations and weather. Norwegian law permits hunting in the Vestfjorden district from March 15 to June 30 and from July 22 to September 14. On Sundays it is illegal to hunt in waters less than 30 miles from shore. Because the little piked whale does not have a large, conspicuous spout and exposes its body only slightly above the water surface, it is almost impossible to see at any distance in a choppy sea. For this reason nearly all hunting takes place during periods of calm weather or light winds.

Like most hunters, the Vestfjorden whalers take maximum advantage of good weather and daylight. Normally the catcher boats cruise off the south coast of the Lofoten Islands in search of whales which, on their northward migration, turn into Vestfjorden. Until a boat is made fast to a whale the most important part of the hunt is the constant lookout. As many men as possible will mount watch at the masthead or conning tower (Fig. 22, 23).

Once a whale is spotted the catcher begins to close for the kill. At this point some animals may approach the boat and, from curiosity or some other cause, they will circle so near that a kill is almost certain. But most whales are brought into cannon range only after a prolonged, patient hunt during which the whaler is required constantly to change speed and course. Although the 50-mm cannon will carry reasonably accurately for about 70 yards, those gunners interviewed said they preferred to fire at distances of about 20–30 yards.

The operation of a whaling harpoon cannon is a highly skilled job. The gunner must know the behavior of the whale intimately in order to anticipate the animal's movements and point of surfacing. Within a few seconds he must estimate the firing range to within about 5 yards. Should an unbent harpoon, carrying true from a properly mounted cannon, strike the water short of the target, it will often continue on a straight course just under the surface for a distance of up to 10 yards. Damaged harpoons or weapons fired from an insecure cannon have a tendency to breach above the water. The Vestfjorden whale gunners were in agreement that any hunter familiar with animal behavior would quickly learn the additional skills necessary for a competent harpooner.

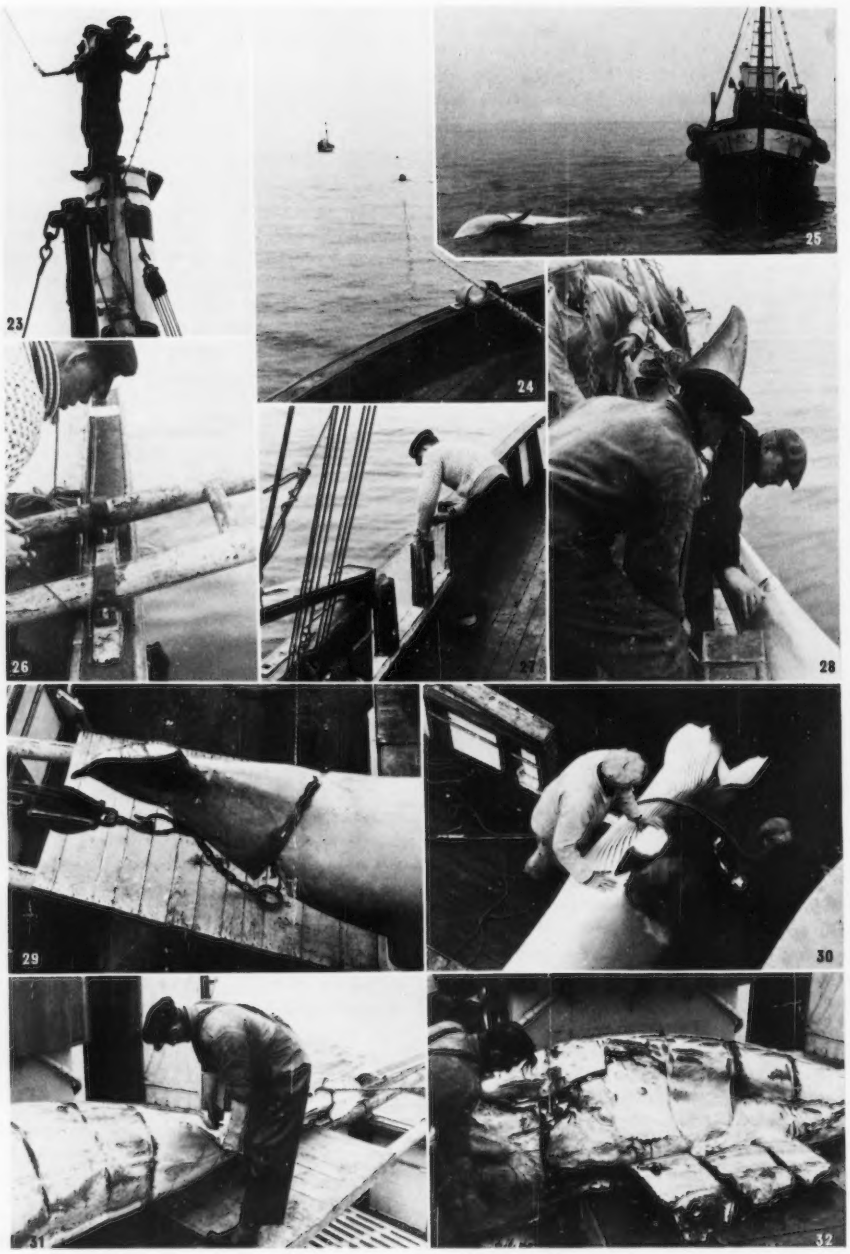
In almost all cases the 50-mm cannon propels the harpoon completely through the little piked whale, inflicting a crippling or fatal wound. Nevertheless, death is seldom instantaneous and the whalers must pay out lines and floats while the dying animal expends its last energy (Fig. 24). At the time of death or shortly after, the hunter hauls the whale along side, thrusts an air lance into the tongue or body caviy and injects enough compressed air to keep the animal afloat (Fig. 25).

Meanwhile some crew members have fastened the outrigger in place, and if it is a large whale, the support cables. The loading door is opened and the block and tackle rigged in preparation for pulling the dead whale on board (Fig. 26, 27).

First the whale's tail is drawn above water by the deck winch and line. The flukes are cut off to facilitate the subsequent handling of the animal on board. Then deep cuts are made in the top and bottom of the caudal peduncle and a heavy chain fastened around the tail and cuts (Fig. 28). This, in turn, is attached to the outrigger block and tackle and the whole animal is neatly and quickly pulled on to the boat by means of the deck winch (Fig. 29–30). A large hook, secured to the boat's side opposite the outrigger, is embedded in the animal's back or side allowing the carcass to be stretched relatively taut and immobile. Two hooks are often used to help fasten large whales. The loading operation is extremely efficient and usually takes only a few minutes to complete.

Preliminary Butchering and Storage

Butchering of the whale can begin whenever the captain chooses. Usually this is soon after the animal is killed because the deck must be cleared to accommodate a possible second kill. One or two crew members are given the task of butchering while the remainder operate the boat or stand watch in search of more whales.



FIGURES 23–32. Catching and flensing minke whale (*Balaenoptera acutorostrata*).

FIG. 23. Lookouts posted at the masthead; Vestfjorden, August 1964; FIG. 24. Wounded whale dragging floats; Vestfjorden, August 1964; FIG. 25. Dead whale inflated with compressed air; Vestfjorden, August 1964; FIG. 26. Outrigger being fastened to rail of boat; FIG. 27. Loading door being opened; FIG. 28. First cuts are made in the peduncle before outrigger cable is attached; FIG. 29. Chain hitched to outrigger block and tackle; FIG. 30. Whale pulled on deck through the loading door; FIG. 31. The blubber is removed; FIG. 32. The meat is removed.

First the forward part of the main deck is covered with white painted wooden racks especially designed to keep the meat away from the deck and to allow cool air to circulate around the freshly butchered meat. A single cut is made from just above and behind the whale's flipper lengthwise to the tail. From this horizontal cut a series of vertical incisions are made around the animal's body to about the middle of the underside. These cuts are about one foot apart. First the blubber is carefully stripped from the meat and deposited on the after deck (Fig. 31). Next the meat is cut away in large pieces, each weighing 20–25 kg (Fig. 32). The thick white gristle covering of the meat is placed against the cooling rack, affording an added measure of hygenic protection. Whether or not the meat is graded as top quality depends upon the age of the whale, the season of capture, and the manner in which the meat was cut and handled on board ship and by the packer.

Surprisingly enough, the whaler is not paid according to the varying amounts of different quality meat he delivers to a packer; instead he receives one set price for the entire catch. This reduces the incentive of a whaler to process the meat carefully. On the other hand, a whaler who consistently delivers poorly butchered meat may be unable to find a buyer or may suffer prosecution under the Norwegian law regulating hygenic conditions on board whale catchers.

The meat is removed from the carcass without rupturing the stomach cavity or intestines. Instead, the ribs are detached from the exposed, upper side of the animal, and the entrails neatly pulled out and forward toward the head. Only the liver and heart are saved; the remainder is thrown overboard. When all available meat and blubber have been cut from the body and head, the chain holding the animal to the outrigger is released. Normally the whale's head is so heavy in comparison to the stripped body, that with a little effort by the crew it slides through the loading door, dragging the entire carcass into the sea.

Almost maximum use is made of the whales captured in the Vestfjorden region. All the meat, including that clinging to the ribs, is saved together with the tongue, liver, heart and blubber. The whale's skeleton, baleen, kidneys, stomach, intestines, a small portion of the tail and some blubber and skin around the head are discarded. A market for baleen, kidneys and intestines could reduce this loss of potential by-products.

Most of the little piked whales captured in the Vestfjorden area are immature animals. On the average they yielded about 1120 kg of meat and 425 kg of blubber during the 1963 season.

Delivery and Sale to Whale Products' Buyer

Soon after the whaling captain has loaded a whale on board his boat, he contacts, by radio telephone, the nearest office of Norges Raafisklag (Norway's Raw Fish Organization) reporting his location and approximate size of catch. This organization is the official sales agency representing the north Norwegian whalers. The raw whale products are sold under an auction system by the Raafisklag who determine which local land-based buyer will receive the meat and informs the whaler to that effect by radio telephone. In other words, the whaler, while still at sea, knows where, at what price and to whom he shall sell his meat and blubber.

In the Vestfjorden district a minimum price of 2.25 kroner per kilogram of meat and 0.20 kroner per kilogram of blubber was set by Norges Raafisklag in 1964. Prices vary from one hunting district to another, however, and from one month to the next. As mentioned before, the quality of meat depends very much on the season of kill. For example, spring whales usually give the greatest amount of whale beef and their lean meat can be frozen more successfully than fatty meat obtained in late summer and autumn. For these reasons, meat prices are normally highest in spring and decline as the hunting season progresses. The average monthly price changes for the period 1954–60 which have been summarized by Holm (1962, p. 249), as follows:

Month	Prices 1954–60 Kroner/Kilogram
March	2.20
April	1.97
May	1.40
June	1.34
July	1.47
August	1.45
September	1.58

Since 1959 the average price paid the hunter for little piked whale meat and blubber, for Norway as a whole, has been as given in Table 12.

When a captain is convinced a particular hunt will yield no more whales, he sets his course for the buyer's wharf. Under the cool conditions of the Vestfjorden climate the meat can remain on board unrefrigerated for 2 days without any damage to its quality. While on the deck the meat is covered with a tarpaulin.

Offloading the Whale Products

The catch boat notifies the buyer by radio telephone of his approximate arrival time and

FIGURES 33–39. Processing meat and blubber ashore.

FIG. 33. Unloading whale meat from small whale catcher; FIG. 34. Unloading and weighing apparatus (from left to right: scales, unloading bucket, and meat sorting table); Skrova, August 1964; FIG. 35. The district veterinarian inspects whale meat in presence of the packer; Svolvaer, August 1964; FIG. 36. Whale meat being butchered in packing plant (note uncut meat in right, background); Svolvaer, August 1964; FIG. 37. Blubber dumped on packer's dock to wait further shipment; Skrova, August 1964; FIG. 38. Ready packed frozen whale meat being loaded for shipment to Oslo; Skrova, August 1964; FIG. 39. Animal oil processing plant; Tromsø, August 1964.

TABLE 12. Average price paid to hunter for meat and blubber from minke whale (*Balaenoptera acutorostrata*), 1959–63.

Year	Kroner per kilogram	
	Meat	Blubber
1959	1.48	Unknown
1960	1.86	Unknown
1961	1.65	0.35
1962	1.79	0.25
1963	1.77	0.29

weight of meat and blubber. This allows the buyer to arrange his landing and storage facilities and recruit butchers and packers for the further preparation of meat products.

Unloading begins as soon as the boat arrives at the buyer's wharf. A clean, white painted, wooden container is lowered from the dock to boat deck where crew members fill it with meat chunks (Fig. 33). On the dock the container is emptied onto a clean white wooden bench placed opposite to the scales (Fig. 34). The buyer and boat captain, or his representative, weigh out the meat in 100-kg loads. A record of each load is kept by the buyer and whaler. The 100-kg loads are then dumped into clean wooden or metal wheel barrows and moved into the packing house. It is not uncommon for experienced crew and dockside workers to unload meat at a rate of 10,000 kg/h.

Food Inspection System

Until September 1964, the treatment and packing of whale meat was regulated by the ministry of Manufacturing Industries under the Parliamentary Act of June 16th, 1939 concerning whale hunting, and the Royal Decree of April 30th, 1948. Since September 1964, administration of this act has become the responsibility of the Ministry of Fisheries. Before any packer can receive and process whale meat he must be authorized by the government. The granted authorization may be cancelled if the plant or the working rooms or the treatment of whale meat at the place of packing does not meet the requirements stipulated by government regulations.

Enforcement of the law is the responsibility of the whaling inspector and whaling office of the Hunting Office of the Ministry of Fisheries and the District Veterinarian, an official of the Ministry of Landuse. These men inspect the catcher boats, their crews, all packing facilities and the meat when it is delivered to the packer (Fig. 35). Should the veterinarian be unable to inspect the meat before packing, he will often make sample tests on the processed products prior to their shipment to wholesale and retail outlets. The veterinarian has the power to determine whether or not the meat shall be used for human consumption or must be processed as animal food. Failure to follow the law governing hygenic treatment of whale meat can mean a whaler or packer will forfeit his permit to hunt or process whales.

Food Preparation, Meat, and Meat By-Products

Usually the packer begins to process the fresh meat as soon as it arrives. Expert cutters carve the large 20- or 25-kg meat chunks into sizes determined by the packer's intended future use of the meat (Fig. 36). At this point the meat is classified as "first class" suitable for steaks, "small meat" used for human food either as steak, stew beef, or incorporated in meat products, and "animal food" processed for use by fur farms or household pets.

First-class meat is usually prepared for resale as a fresh product or as a deep frozen and packaged item. The fresh meat is cut into 2–3 kg pieces and placed in new wooden boxes between layers of cracked ice. Each box holds about 20–40 kg of meat. In this form the fresh product is ready for immediate shipment to the large retail markets of southern Norway.

Meat prepared for deep freezing can be packed in bulk, as in the case of fresh meat, but more often it is cut into small pieces weighing from 400 to 1000 g. These can be wrapped in thin plastic for wholesale distribution or packed in attractive wrappers ready for the retail stores. Some large commercial food product companies contract with the small whale meat packers of northern Norway for the preparation of a finished frozen product that can be shipped directly to the retail outlets without additional processing.

Most small packing plants in northern Norway do not process the "small meat" into secondary food products, but sell the raw meat to other factories. Here it is made into commercial processed foods which range from sausages to meat cakes and pressed luncheon meats. Sometimes, whale meat is combined with other meats, such as pork or perhaps reindeer, to form a particular brand of canned food. Small meat is rarely used as animal food but now and again a fur farmer may wish to give his animals high quality food or, if caught short of feed, he may purchase the relatively costly small meat.

The third class of whale meat, animal food, goes directly to mink and fox farms. A reasonably large amount is processed as dog and cat food. Under Norwegian law it is illegal to use this meat for human consumption.

Meat Storage

All fresh meat delivered to the packer is stored either in cold or freezing rooms. Whale catchers that have hunted offshore waters for several weeks at a time carry a load of new, clean commercially made ice that is packed around the meat. In all cases, whale meat is kept under refrigerated conditions from the moment it reaches the packer, and sometimes before, until it is sold by the retailer. Meat processed as a frozen product is subjected to extremely low temperatures for a short period and then stored for weeks or months at about −25 C. Prolonged frozen storage does not seem to damage the quality of the meat which is well protected from the air. In contrast, fresh whale meat in direct contact with ice can develop an "ice burn" or discoloration. Originally the offshore whalers placed cracked ice between each layer of meat but this, it was learned, increased the frequency of ice-burned meat. At present it is standard practice to pack ice around the entire load of meat but not between individual pieces or layers. Fresh meat destined for immediate resale in southern Norway is packed in thin plastic between ice layers. It is kept in a cold room for a short period, a few hours or a day, until it can be placed in the refrigeration compartment of a southbound ship.

Blubber Preparation and Storage

The packer who purchases whale meat normally accepts the blubber also. Because there is no commercial whale oil processing plant in the Vestfjorden region, the packers must send their raw whale blubber north to Tromsø. The price paid for blubber is very low and the income to the packer appears to be so slight that little care is given to storage. Usually the blubber strips are dumped on the dock or placed in metal drums to await further transport (Fig. 37). This casual and sometimes prolonged method of storage means some whale oil is lost through the natural rendering process. When a number of packers have accumulated about 30–40 tons of blubber, a ship is chartered to carry it to Tromsø. Some catcher boats operating in offshore waters will first deliver their blubber to Tromsø, and then continue south to the Vestfjorden area to sell their meat cargo.

Statistscal Reporting System

The Whale Inspection Branch of the Hunting Office of the Norwegian Ministry of Fisheries supervises a well-organized program of statistical reporting on all important aspects of small whale hunting in Norway. When a whaling captain applies for his annual hunting license, he submits a form giving vital statistics on his boat and equipment. Furthermore, the hunter is required to fill out a form for each whale killed, giving such information as the species, date and place of kill, length, sex, whether it is a lactating female, and whether it is gravid and, if so, the length of the fetus. The form also contains questions on the amount of meat, blubber, and bone obtained from the whale and the price the hunter received for these products. The buyer's name is listed. At the end of each season the whaling captain completes a third form giving, again, vital statistics on his vessel and equipment and a month by month summary of all whale species captured.

These statistical data are compiled by the Hunting Office into an annual report called the Résumé for the Small Whale Hunt ("Oversikt over Smaahvalfangsten"; see Anon. 1962, 1963c). These data are then made available to the marine biologists in the Whale Research Institute at the University of Oslo where the scientific information is used.

One reason for the apparently satisfactory relationship between hunter, government official, and marine biologist is the hunter's confidence that his reports will not be passed on to other government agencies, such as the Ministry of Internal Revenue. Moreover, the Norwegian hunter appears sophisticated enough to accept the fact that hunting regulations must be based on sound biological knowledge. Even though he may disagree with opinions of the scientist, it is to the hunter's credit that he continues to submit detailed, accurate reports even when he realizes this information may show, conclusively, that the accumulated kill is biologically harmful and, therefore, must be reduced.

Although the present system provides complete economic statistics on the hunt, it does not cover the packer, wholesaler, and retailer. Furthermore, the number of catcher boats that may move from one hunting ground to another each season are not listed in the annual report. Lastly, one cannot calculate the exact economic importance of whaling to the average boat in relation to other seasonal sources of income, especially fishing. A useful addition to the reporting scheme on fishing would be the statistical separation of all boats used as whalers from March to September each year. It would also be helpful to know the actual production amounts of the various types of whale meat products.

Summary of Whale Hunting Costs

The annual costs for whale catching equipment have been mentioned already. Other major operating costs are crew wages, food, insurance, and fuel. To estimate these costs exactly is difficult

because statistics are not available. But some worthwhile conclusions can be made from observations obtained during August 1964, and assumptions from other data.

In keeping with the whaling tradition, the crew of a Norwegian catcher boat is paid according to a share system. This system can vary from boat to boat and with the experience of an individual seaman. But, in general, each crewman receives one share, the boat two shares, and the whaling cannon one. Thus every member of a five man crew would be paid one eighth of the gross profit of the boat's catch, while the boat captain would take one half of the profit for himself, the boat and cannon.

It seems that on most catcher boats the individual sailors supply their own food which they store in separate, private lockers. The captain may purchase such bulk staples as coffee, sugar, salt, and pepper. Fresh whale meat, of course, supplies an important, inexpensive main dish on many voyages. Food costs probably do not exceed five kroner per man per day.

Insurance rates vary with the type of policy and the age of the vessel and its equipment. New boats may be charged about 25 kroner per 1000 kroner of value, while the rate for old boats may be as high as 40 kroner per 1000 kroner of value. For the purpose of this report I have assumed insurance on boat and crew to be 3.5% of the investment and collision insurance to be 1.0%. Insurance on a boat valued at 100,000 kroner would be 4500 kroner per year. For the average 110-day whaling season this would cost about 1360 kroner.

The final important operating cost is fuel; fuel for the boat's engine, the forecastle stove, and a main galley stove. The first two use ordinary fuel oil, while the latter often burns propane gas. No exact statistical data are available on the total number of hours a boat spends at sea hunting each season. I will assume here that the average hunting day is 15 h long, a figure which takes into account the fact that summer sunlight in the high latitudes can provide around the clock hunting conditions. It is assumed that the boat's engine and forecastle stove consume fuel for 15 h per hunting day and the galley stove for 2 h per day.

Measurements of the standard "fisherman's stove" in the forecastle showed the rate of fuel consumption as about 1 liter per hunting day. The rate of fuel consumption for boat engines varies with the horsepower, type of engine, and speed. It would seem that the average whale catcher in the Vestfjorden district used from 10 to 20 liters of fuel per hour or an average of about 15 liters per hour. This would be about 225 liters per hunting day. The official list price of diesel oil in northern Norway is 0.25 kroner per liter. A whale hunter may purchase oil for somewhat less under a credit card system or wholesale buying. A reasonable estimate of all fuel oil costs incurred by the average whaling boat during a 110-day hunting season is about 6000 kroner. If one adds to this the equipment costs summarized earlier and other costs, then it can be assumed that the average Vestfjorden whale catcher needs at least 14,000 kroner to operate for an average hunting season.[10]

Based on the 1962 and 1963 statistics, it appears that the average Vestfjorden whaler kills 15 little piked or minke whales per season. At an average yield of 1120 kg of meat and 425 kg of blubber per whale, this would mean hunting costs would be about 0.60 kroner per kilogram of meat and blubber.

In 1963 the average little piked whale captured in the Vestfjorden region sold to the packer for 2440 kroner. In 1963 the hunter earned about 1.57 kroner per kilogram from the average whale. Under the new 1964 price system, the average whale was worth about 2615 kroner or 1.68 kroner/kg. A kill of 15 whales in 1963 would give a gross income of 36,600 kroner. The gross income for the average boat employing a crew of five men would be 18,300 kroner for boat, cannon, and whaling captain and 4575 kroner for each crew member. Operating costs and income can be summarized as in Table 13.[11]

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[10]The average whaling seasons in 1962 and 1963 was about 110 days, but the number of hunting days or days at sea was less since bad weather very often inhibits whaling. (IC)

[11]I think Mr Foote has misunderstood some of the information from the whalers. For example, in Table 13 it appears that the crew gets more money than the owner. There are other such misunderstandings from here on in the work ... as well as much valuable information. Remember, also, that this publication describes the situation in 1964 and earlier. Some points are: 1) Working expenses are paid from the total catch; 2) As working expenses means engines fuel, lubricating oil, grease, twist, fuel for heating, telephone, telegrams and ice; 3) For the vessel, gun and equipment the share is calculated according to the length of the vessel and the number of the crew:

Vessel	from	40	ft	to	49	ft until 4 man	— 40%
"	"	50	"	"	59	" " 5 "	— 44%
"	"	60	"	"	69	" " 6 "	— 46%
"	"	70	"	"	75	" " 6 "	— 48%
"	"	76	"	"	89	" " 8 "	— 50%
"	"	90	"	"	105	" " 8(9) "	— 55%

All this is from: Rules for clearing between the crew and the vessel owner established by Norges Fiskarlags Landsoppgjørsnemnd, 1968. (IC)

TABLE 13. Estimated operating costs and income of a catcher boat with a crew of five (see text).

	Norwegian kroner	
	1963	1964
Gross earnings (15 whales)	36,600	39,100
Operating expenses	14,000	14,000
Net profit (unadjusted)	22,600	25,100
Gross earning to owner	18,300	19,550
Net profit to owner	4,300	5,550
Earning per crewman	4,575	4,887
Average daily wage per crewman	41.59	44.42
Average daily wage per captain	39.09	50.45
Hourly wage 15 h/crew	2.77	2.96

SUMMARY OF FOOD PACKING COSTS

As mentioned earlier, there are no exact statistics available on the production costs for whale meat packing and processing. Several examples of packing were studied, however, which appear to give an adequate, general picture of the meat packing industry.

Wages for unskilled labor in the packing plants of Skrova and Svolvaer in the Vestfjorden district ranged from 5.50 to 6.50 kroner/h. The butchers were paid a higher wage. Some packers employed skilled or semi-skilled butchers on a straight hourly pay of 6.50 or 7.50 kroner. Since a good butcher can process from 200 to 300 kilograms per hour, average production costs under the hourly wage system would be about 0.053 kroner per kilogram of meat.

Other packers pay wages according to the production of different quality meats. For example, in one plant butchers earned as follows:

	Kroner per kilogram
First-class beef	0.11
Second-class beef	0.10
Small meat	0.07
Animal food	0.06
Average for all meats	0.085

In this particular plant a skilled butcher could earn from 100 to 200 kroner/day. It can also be seen that butchers working under this system will tend to cut and upgrade the meat toward the highest qualities. In any case, men working by the hour would seem to earn just over one half the wage given butchers who are paid according to the quality of finished product.

In addition to these labor costs, the packer is required to pay 0.01 kroner per kilogram of processed meat for the hygenic inspection service provided by the district veterinarian. For each kilogram of human food produced he pays 0.005 kroner into a government insurance fund; this money can be refunded at a later date.

A study of the unloading, butchering, and packing of 6000 kg of whale meat showed production costs to be as follows:

Operation	Cost per kilogram in kroner
Unloading	0.019
Meat inspection	0.01
Butchering	0.082
Packing	0.006
Total	0.117

SUMMARY OF HUNTING AND PACKING COSTS

On the basis of the foregoing evidence, the average costs for the hunting and packing of whale meat in the Vestfjorden district can be summarized as follows:

Operation	Cost per kilogram in kroner
Hunting	0.60
Unloading	0.02
Meat inspection	0.01
Butchering	0.08
Packing	0.01
Total	0.72

WHOLESALE OF MEAT PRODUCTS

It has been mentioned already that in 1964 a minimum price policy was inaugurated whereby the whale hunters of the Vestfjorden region receive at least 2.25 kroner/kg for whale meat and 0.20 kroner/kg for blubber. The packer probably pays an additional 0.12 kroner/kg to unload, inspect, butcher, and wrap the meat. To this must be added the packer's expenditures for plant depreciation, equipment, and storage. It was not possible to obtain exact data on these costs.

Wholesale prices in the Vestfjorden region vary with the quality of the meat and market conditions. In general, 1 kg of first-class beef wholesales for 3.70–5.00 kroner, second-class beef about 3.50 kroner, small meat about 2.25 kroner, and animal food about 1.30 kroner/kg.

The percentage of various quality meats obtained from a single whale differs widely from one animal to another. In general, animals captured in offshore waters late in the autumn yield a lower amount of first-class meat than do whales captured in the Vestfjorden district in late spring and summer. In 1963, 40% of all whale meat was beef, 60% small meat and animal food. For the purpose of this report I assumed that the

average little piked whale of the Vestfjorden area gives about 40% beef, 40% small meat, and 20% animal food. It is further assumed that the average wholesale prices are 4.00 kroner/kg for beef, 2.25 kroner for small meat, and 1.30 kroner for animal food. During those seasonal periods when the little piked whales give a higher percentage of good quality meat, the price to the hunter increases, sometimes to as much as 4.00 kroner/kg. This means the wholesaler's profit remains relatively constant.

Based on these assumptions, it can be figured that the wholesaler receives for the average 1120 kg of whale about 3091 kroner or 2.75 kroner/kg. As the following table suggests, the average wholesaler's profit margin is apparently quite good.

	Cost in kroner per kilogram
Hunter	2.25
Processing	0.12
Storage	?
Total	2.37+

It is clear that a packer makes his greatest profit on high grade beef, not on meat sold as animal food. Because the packer must buy the meat before he has seen it, he always runs the risk of accepting a load in which the amount of beef quality meat is very low. This is less true for the Vestfjorden region, where the immature whales captured usually yield high percentages of beef, than for the offshore grounds where late summer and early autumn whales have a high fat content, often in the form of marbled meat.

As an illustration of the packer's risk, in late summer 1964, one Svolvaer packer purchased 6000 kg of meat for 12,000 kroner. Much to his dismay the meat proved to be 20% second-class beef, 50% small meat, and 30% animal food. At current prices he just barely met expenses for the processing and storage of this load.

The average wholesale packer of the Vestfjorden region is able to profit from the purchase, processing, and sale of whale meat because in many cases his capital investment in buildings, and docking facilities have been amortized over decades of use. His recent investments in modern cooling and freezing equipment are covered, in great part, not by business generated from small whaling, but from fishing. In other words, the wholesaler is geared to process large amounts of fish products which, in turn, enables him to handle relatively small amounts of whale meat. It is doubtful whether many Vestfjorden packers could survive on the purchase and sale of whale meat alone.

Transport of Whale Meat Products

The Vestfjorden packers are obliged to ship fresh or frozen whale meat products, including animal food, from the Lofoten region by coastal steamer (Fig. 38). Most of the quality beef is shipped to Trondheim where it is transferred to refrigerated railway cars or trucks and carried further to the large urban market around Oslo. Some meat may be sent directly to Bergen. Approximate transportation charges from Svolvaer, in the Vestfjorden area, to Oslo are as follows:

Transport	Kroner per kilogram
Costal Steamer (Svolvaer–Trondheim)	0.44
Railway (Trondheim–Oslo)	0.20
Total	0.64

Fresh meat shipped from Svolvaer can reach Oslo in about 3 days. In this case the meat is repacked in new ice during its transshipment through Trondheim. Frozen meat products can be shipped directly to Oslo by steamer because time is not an important factor.

Summary of Whale Oil Processing

As mentioned earlier, all blubber purchased in the Vestfjorden district is shipped north for processing in Tromsø. Raw blubber is worth 0.20 kroner/kg in Vestfjorden, transport to Tromsø costs 0.05 kroner/kg and the Tromsø purchase price is 0.40 kroner/kg. The Vestfjorden packer thus makes 0.15 kroner/kg or about 63.75 kroner from the average whale giving 425 kg of raw blubber.

In Tromsø the blubber is delivered to one of several plants equipped to process whale blubber (Fig. 39). The blubber strips are carried from the wharf to a chopping machine where they are cut into small pieces. These, in turn, are carried by conveyor belt up into the reduction plant and dumped into large boilers holding about 7 tons. The blubber is then heated to 100–110° C by live steam circulated through the boiler. Cooking time is normally from 3 to 5 h.

After the blubber has cooked, it is left to cool from 1 to 4 h. At this time clear whale oil will accumulate at the boiler's top, while the heavier, impure products sink. The pure oil is siphoned off, pumped through a separator, and piped directly to storage tanks in a condition ready for immediate wholesale. Liquid remaining in the boilers is heated again before being passed through a system of large centrifuge machines. About 20% of this preheated liquid is pure whale oil.

At the bottom of the boiler is a consolidated mass of residue. This is combined with the residue from the centrifuges; then it is pressed and carried to a drying plant where it is heated in two, long rotating cylinders. The dried residue is pulverized into a whale oil meal. Liquid pressed from the residue is circulated through the centrifuges to extract additional oil. The dried whale oil meal contains about 10% of water and from 8 to 12% whale oil. Raw blubber from a single 7-ton boiler will produce about 500 kg of whale oil meal. The finished product is packed into 50-kg bags ready for wholesale and shipment.

The oil content of whale blubber varies from one season to the next. In spring it may contain from 28 to 30% oil, while in autumn it can be as high as 45%. One kilogram of raw blubber from an autumn whale might yield 420 g of whale oil, 220 g of whale oil meal, and 360 g of water. Wholesale prices for whale oil and whale oil meal fluctuate from month to month and are, in large part, governed by the world market for animal oil products. In late summer 1964, whale oil in Tromsø was selling for about 1.35 kroner/kg and whale oil meal at about 1.00 kroner/kg.

Although no exact information on production costs for whale oil and meal are available, a study of two Tromsø plants provided some useful observations. In general, it would seem that all production costs amount to somewhat less than 0.20 kroner/kg of raw blubber processed. At current prices a load of blubber yielding 40% oil and 20% meal would give a net profit of about 0.08 kroner/kg.

As in the case of the whale meat packer, the production of whale oil and meal is intimately bound to the processing of fish oil and fish meal. The entire plant, from dock facilities to boilers, centrifuges, and meal drying machines are all designed to process large amounts of fish. The production and sale of whale blubber derivatives are of secondary importance. It seems doubtful that any large north Norwegian processing plant could survive on the production of whale blubber alone.

Whale oil and meal produced in Tromsø are shipped to southern Norway or exported. Some oil is sold to refineries for further processing, some oil is sold directly for use as a raw product. The whale oil meal is a finished product and is sold directly to a distributor or retailer. The oil is usually pumped directly into a bulk carrier. Seldom is it transported in drums or small containers. The meal is shipped by ordinary cargo ship as dry freight.

Retail Preparation and Sale of Meat Products

The Vestfjorden packer produces a finished whale meat product cut, weighed, and wrapped for direct retail sale. This is almost always a frozen meat prepared under contract with a large, commercial food producing company. Distribution is made under widely known brand names to a large number of retail outlets that carry the other food products of the company.

Wholesale whale meat, as bulk frozen or fresh products, can be distributed in two ways. A retailer can purchase his meat directly from the north Norwegian packer or he can buy it from a distributor in the immediate urban area. Usually only retailers with a large market can afford to make direct wholesale purchases from the packer. In these cases the retailer often buys fresh meat in the Vestfjorden district and makes arrangements for its proper handling throughout the long journey from, say, Svolvaer to Oslo. This usually requires re-icing and packing in Trondheim. Once in Oslo the large, 2- or 3-kg pieces, are cut into convenient steaks and placed on sale. Some meat can be processed by the retailer for resale as a frozen product.

More often, it seems, the average retailer buys his fresh whale meat from an urban distributor who has purchased relatively large quantities of meat in 20- to 40-kg cases directly from the north Norwegian packer or from a broker in Trondheim. The Oslo distributor resells the meat by the case for export or to the local dealers who then resell it in any amount, either as a retail product to the consumer or as a wholesale product to small retail stores that cannot afford to carry a large inventory of fresh meat. Some meat, then, can be sold a total of 6 times, from hunter to packer, packer to Trondheim broker, broker to Oslo distributor, distributor to dealer, dealer to retailer, and finally, retailer to consumer. Because the meat sold in this manner must compete with products shipped directly from packer to retailer, the consumer does not find a wide spread of retail prices. On the other hand, the retailer who can afford to purchase directly from the packer stands to make the highest profit. Whale meat normally retails in Oslo at about one half the price of beef, or about 8.00–9.00 kroner/kg.

A very generalized breakdown of costs and profits for grade A fresh whale beef is given in Table 14.

Just why fresh whale meat should undersell beef by such a large margin is not clear. Certainly, a grade A whale beef steak compares well in texture and taste with good cow beef. On the other hand, the Norwegian consumer has had to learn to accept whale meat into his diet. This has taken at least 20 yr and the process is by no means complete. Only recently, was whale meat introduced into Sweden. A well-planned adver-

TABLE 14. Generalized breakdown of costs and profits for grade A fresh minke whale beef (see text).

	Kroner per kilogram		
Distributor	Cost	Sale	Profit
Hunter	0.60	1.68	1.08
Packer	2.49	4.00	1.51
Distributor	4.80	5.50	0.70
Retailer	5.50	8.50	3.00

tizing campaign appears to have accelerated its acceptance by the Swedish public.

There is a little-discussed but well-recognized fact that the whale meat packers themselves and their frozen meat product may be important causes for low prices. As mentioned before, packers who pay their butchers according to the quality of meat produced create a situation whereby the butcher tends to upgrade the beef. This means that second-grade beef may be packed and sold as first grade. In addition, the retail frozen meat packages often contain small, irregular meat slices included in order to make the packages a set weight. The Norwegian housewife is naturally irritated when she unwraps a package of supposed steaks to find some are useless for this purpose. A consumer who has developed a poor opinion of whale meat based on the frozen product will probably not purchase fresh meat unless the price is very attractive.

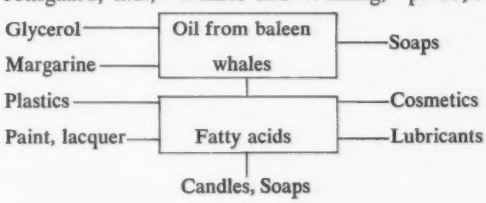
Improvement in the whale meat industry may require a concerted campaign whereby the product is distributed not as a low-priced, inferior alternative to beef, but as a specialty meat available only in limited amounts. Certainly, more imagination in the marketing of the product should result in a gradual price increase.

RETAIL PREPARATION AND SALE OF OIL PRODUCTS

Whale oil from the north Norwegian small whale industry competes with and enters into the world market for animal and plant oils, especially whale oil produced from the large antarctic commercial hunt. But unlike the Norwegian hunt in the Antarctic, which traditionally has been for whale oil, the small whale industry of northern Norway is oriented primarily toward the production and sale of whale meat for human consumption. Nevertheless, the small whale hunter is able to sell raw blubber because local industry in northern Norway, built to process fish meal and oil products, can refine whale blubber. This they are willing to do because the oil enters into a well-established processing and market system based on fish oil and the antarctic whale oil. It is possible that should antarctic whale oil cease to be used in any great quantities in Norway or other parts of Europe, the north Norwegian small whaling industry will be hard pressed to find a suitable market for their relatively low production of oil. [Antarctic whaling from Norway stopped in the season 1967/68. (IC)]

Some raw whale oil refined in northern Norway can be used directly by industrial processes such as tanning. Most of the oil, to be commercially valuable, must undergo a second elaborate refining. There are several plants in Norway, located in Bergen and Sandefjord for example, that have the necessary machinery for this. Again, these plants are built for the processing of fish oils or antarctic whale oil, not the small quantities of raw oil produced from the north Norwegian hunt.

In the large refinery the oil is carefully separated according to its various chemical and physical properties. It is then ready to be sold on the open market for such uses (diagram below from Jonsgaard, n.d., "Whales and Whaling," p. 10):



Conclusions

From the evidence presented in this report, small whale hunting in northern Norway emerges as a subsidiary industry. It exists, at all levels of production, in close relationship to primary producing industries based on fishing or large-scale whale oil production. The degree to which the small whaling industry is viable is questionable because of warning signs disclosed by biological and socioeconomic investigations.

At the moment an average annual catch of 15 whales provides the Vestfjorden whaling captain with a net income of about 5000 kroner.[11] Earnings from the sale of fish probably brings his annual income into line with the average north Norwegian fisherman's income which was between 7,000 and 10,500 kroner in 1961. However, the exact amount of money earned by a whaler during the fishing season is unknown. The importance of the Lofoten cod fishery to the Vestfjorden small whale hunter is also not known.

The Vestfjorden region appears to be a good example of the entire Norwegian small whaling industry. First of all, operating expenses for a Vestfjorden catcher are not radically different

from other boats used in coastal whaling. They are lower than those incurred by large boats hunting offshore waters. Second, the ratio of gross income to expenses, for the whole industry, parallels the Vestfjorden model. The average gross value per whale capture by all small whale hunters was as follows:

Year	Gross average value in kroner
1963	2523
1962	2504
1961	2209
1960	2603
1959	2235

These values agree with the figures presented in this report for Vestfjorden whales; 2440 kroner in 1963 and about 2615 kroner in 1964. If operating expenses are about 130 kroner/day for an average 110-day hunting season, then all boats with a crew of five had to capture at least six whales. The larger the vessel and the crew, the more whales a catcher must kill to meet expenses.

One important problem the industry faces is recruitment of competent, skilled crewmen. A slight mistake by an inexperienced seaman may mean the difference between a successful kill and failure. At the moment, Vestfjorden crew members are probably paid about 45 kroner/day. These earnings compare favorably with wages paid to unskilled labor employed by land-based industries in northern Norway. Nevertheless, the small whaling industry must compete with skilled or semiskilled jobs in urban centers which offer daily wages in excess of 45 kroner/day.

Money, of course, may not be the only reason why north Norwegian whalers are in the business. There seems little doubt that the men enjoy the hunting life at sea. They are proud to be whalers, to stand out in contrast to men solely occupied with fishing. The undeniable excitement of the hunt must be attractive to many men, regardless of their eventual income. Yet this aspect of whaling does not overcome the basic need to support a family and home. Several Vestfjorden captains remarked about the apparent increasing difficulty with which they obtained a competent crew during recent years.

It is obvious that small whale hunting in northern Norway continues only because it is intimately linked to the fishing industry and, to a lesser degree, antarctic whaling. Anything that threatens the north Norwegian fishing industry strikes directly at small whale hunting. First, some captains probably continue whaling only because earnings from the fishing season cover losses incurred from hunting. Second, the purchase, packing, and wholesale of whale meat products operates through a system based on fish production. Third, the processing of whale blubber is done in large plants built to manufacture fish oil and meal and antarctic whale oil. Fourth, an efficient network of telecommunications and navigational aids exists, primarily because the area is frequented by large numbers of fishing vessels. Clearly, the small whale industry of northern Norway survives, in large measure, only because the region has a relatively healthy fishing industry.

The future of north Norwegian small whaling is not clear because biological observations suggest the annual kill of little piked whales may be causing a reduction in the stocks of whales. Jonsgaard (1962a, p. 166) showed that immature whales have been more exploited than mature ones. In his opinion, "the net result must be a reduction in the total stock and a corresponding decrease in the abundance of whales in the whaling fields." There is little doubt that since 1948 the catch of small whales, under 15 ft in length, has steadily decreased.[12]

Perhaps it is not unreasonable to suggest that the small whale hunting industry of northern Norway may soon face a combination of severe problems. First, fishing off the Norwegian coast and Barents Sea has apparently made inroads on the inshore fish stocks. This is especially true of the Lofoten cod. This has resulted in a steady decline of the Vestfjorden cod fishery and, apparently, a similar decline in the whale hunter's earnings from fishing. Second, there seems little doubt that antarctic whaling will suffer further declines in the near future. This may adversely affect the whole whale oil market, particularly in Norway where present buyers may switch to substitute oils. Thirdly, the reduction of minke whale stocks may create a situation where control measures must be so stringent that many captains will no longer find whaling profitable. And fourth, northern Norway has traditionally been an economically depressed area. The constant migration of young people to large urban centers in southern Norway may produce recruitment problems in the whaling industry that cannot be overcome.

One possible solution to an economic decline in

[12]The preliminary analysis presented by O. V. Solvik and Aa. Jonsgaard (I.W.C. doc. 26/14, 1974) indicates that in the old whaling areas for minke whales in the eastern North Atlantic, the stock has not decreased significantly during the period 1960–72. There are also different stocks of minke whales in the Northeast and Northwest Atlantic (Christensen, I. 1974; Minke whale investigations in the Barents Sea and off East and West Greenland in 1973, Fiskets Gang 48: 961–965). (IC)

Norwegian small whale hunting is the exploitation of similar animals off Canada's east coast by Norwegian boats and crews. It is clear that to develop a whaling industry in eastern Canada, it will require a considerable expenditure of capital for equipment, both in boats and shore installations, and time during which a group of novice, albeit experienced seamen learn the art of small whale hunting.

In the long run it may prove most profitable to initiate a program whereby Norwegian whalers are encouraged to exploit whale stocks along the Canadian coast and deliver the meat and oil to Canadian processing plants. This would require a minimum capital outlay by Canadian owners since it is assumed that existing fish processing factories can be geared relatively easily to the secondary function of the seasonal production of whale products.

A successful program of this nature should be based on two facts. One is a sound knowledge of biology and the extent to which particular whale species can be exploited without endangering the stocks or creating an undesirable imbalance in existing ecological conditions. In this case, the whaling enterprise, like most other modern industrial activities, might be encouraged to contribute a fixed percentage of its annual net profit to biological research.

The second fact that should underlie a viable small whale industry in eastern Canada is development of a North American market for whale beef eaten as a luxury meat. It should be recognized from the outset that production will be limited. In order to make a maximum profit the industry should capitalize on this fact by producing a top quality meat. To create this speciality market will require a careful promotion campaign aimed at introducing the meat and teaching the public about its qualities. It is quite certain that the average North American exposed to a properly prepared grade A cut of whale beef, will welcome it as an excellent alternative to cow or steer beef. Of most importance should be the introduction of whale meat on the menus of speciality restaurants. The food catering business, if convinced of the sales value of whale meat, could be the primary outlet for the product.

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Techniques of Live Capture of Smaller Cetacea[1]

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ASPER, E. D. 1975. Techniques of live capture of smaller Cetacea. J. Fish. Res. Board Can. 32: 1191–1196.

Descriptions of the use of seine nets, breakaway hoopnets, and the hand and rope technique are given and illustrated for capturing dolphins and small whales. The seine net appears to be the most efficient and humane method of taking the bottlenose dolphin, *Tursiops truncatus*. The breakaway hoopnet is useful with species that ride the bow of collecting vessels.

ASPER, E. D. 1975. Techniques of live capture of smaller Cetacea. J. Fish. Res. Board Can. 32: 1191–1196.

L'auteur décrit et figure l'usage de sennes, verveux détachables et méthode manuelle avec cable pour la capture des dauphins et des petites baleines. La senne semble être la méthode la plus efficace et la plus humaine de capture du dauphin à gros nez, *Tursiops truncatus*. Le verveux détachable est utile pour la capture des espèces qui suivent la proue des navires collecteurs.

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IN the past two or more decades, several techniques of live capture of smaller Cetacea have been used with success (Newman and McGreer 1966; Anon. 1974, p. 23, 931; Mitchell 1975, p. 68, 74–75; Gray 1964; Wood 1973; and others). As different techniques were developed and tried by independent catchers and personnel at various oceanaria, it was soon realized that what worked well for certain species of cetaceans did not work with others. Today the techniques of live capture vary not only from species to species, but for the same species, depending on their geographical locations and behavioral patterns.

Techniques of Capture

SEINE NET

The seine net technique has become widely accepted as the most efficient and humane method in the live capture of the bottlenose dolphin (*Tursiops truncatus*) in shallow water.

The seine net most commonly used is 400 yards (365.8 m) long, 24 ft (7.3 m) in depth and is constructed of 52 gauge nylon with an 8-inch (203-mm) stretch mesh. The float or cork line should be of suitable size to support the net upright in the water. The lead line should be only heavy enough to assure that the net is on the bottom. If the lead line is too heavy or over-weighted, it is difficult to handle and could endanger the animals when they entangle themselves in the net. If one or more dolphins became entangled near the bottom, they would be able to lift themselves and the net to the surface to breathe.

It is possible to capture the bottlenose dolphin by using a single boat. However, the one boat would have to be large enough to not only support the seine net, but have ample deck space to place the captured dolphin aboard. One boat with these combined requirements generally lacks maneuverability. The optimum collecting equipment should consist of two boats, one to carry the net and make the set, and another to carry the captured dolphin. Each boat should be manned with a minimum of three persons and it is even more efficient if a fourth or fifth person is available. The net boat should have the capability of at least 35 knots with full gear aboard, not only to lay out the net properly, but to outrace the dolphins when making a set.

In addition to the two boats, it would be advisable to use a spotter plane to assist in the initial sighting of dolphins. This would cut back the running and searching time of the boats by as much as 6 h a day.

When the dolphins are first sighted, an attempt should be made to determine the size of the school or pod. It is not impossible to encircle a large number of animals, but it is extremely difficult to maintain control and avoid mortality. The optimum situation would be to limit the number of animals in the set to equal the number of persons available to handle the net in each boat.

If two boats are used, the net boat will begin the setting of the net (Fig. 1) when the dolphins are schooled up and in the appropriate location relative to the net boat's position. The second boat should be

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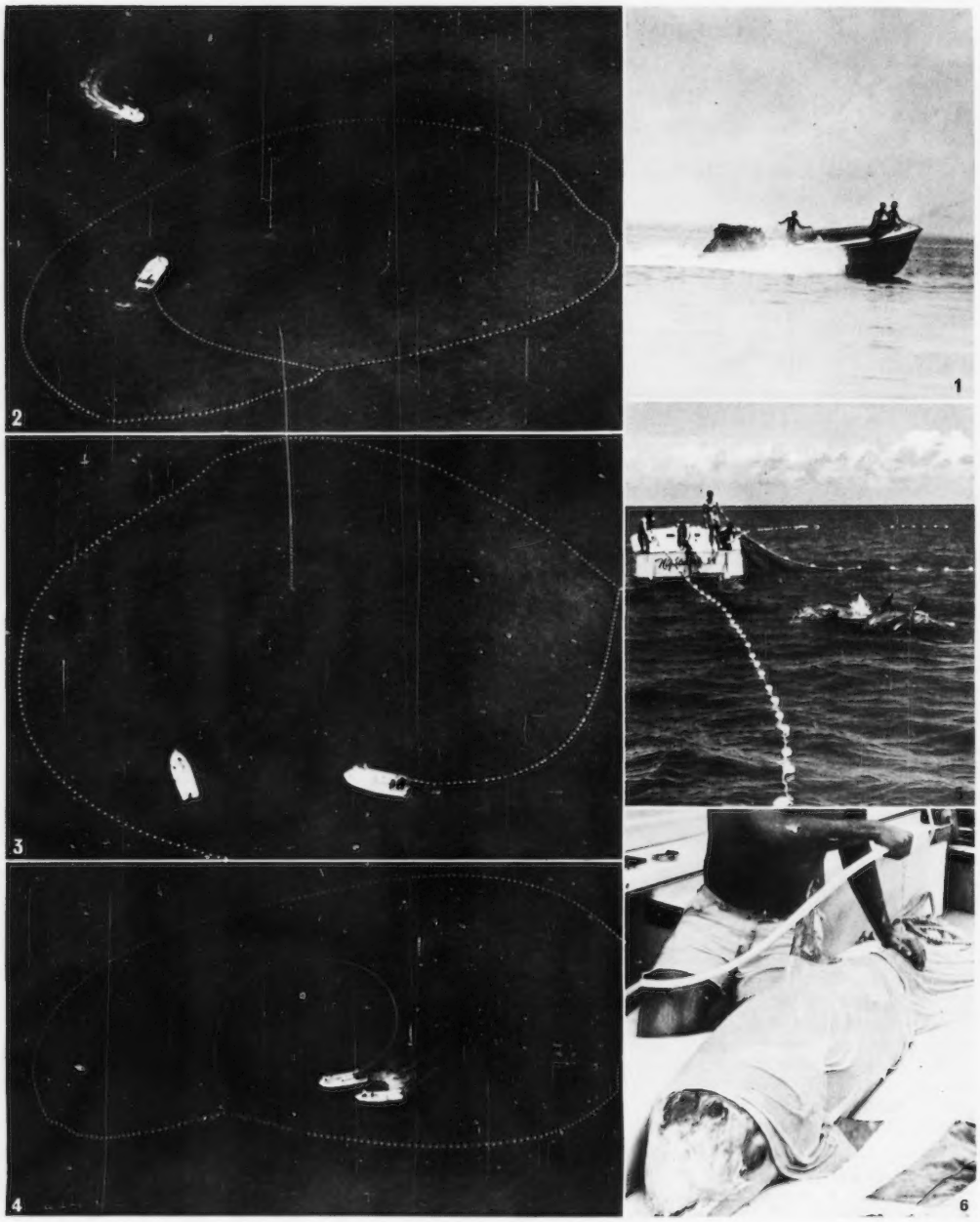


FIGURES 1–6. Capturing dolphins with a seine net

FIG. 1. Net float being thrown over the stern to set the seine net; FIG. 2. Outer set having been made, the net boat begins to lay out the inner circle; FIG. 3. Second boat entering outer circle to assist the net boat; FIG. 4. Illustrating position of both boats nearing the completion of the inner circle; FIG. 5. Dolphins being gathered in the inner circle; FIG. 6. Dolphin aboard the capture boat. (Photos by Edward D. Asper.)

in position to follow the set as it is being made, and to watch for overlaps in the net as well as any animals becoming entangled in the net prematurely.

When the set is complete, a count of the number of dolphins encircled should be made. However, this may not always be possible due to weather or water conditions. The net boat then enters the original or outer circle and begins to lay out a smaller, inner circle (Fig. 2). At this time, the second boat enters the outer circle (Fig. 3) to assist in corralling the dolphins into the inner circle (Fig. 4). Once the inner circle is drawn to within a diameter of approximately 25–40 ft (7.6–12.2 m) (Fig. 5), the dolphins begin to strike the net. In the seine net technique, the dolphins must strike or hit the net to be captured. If all the dolphins hit the net at the same time, they must be pulled up and held at the surface to avoid drowning. Prior to this, both boats should be located alongside the inner circle net on opposite sides. As the dolphins strike the net the float line should be pulled in by the boat closer to the animal. Once a dolphin is alongside it can be measured, sexed, examined for any physical deformities, and then the decision to pull it aboard or to release it can be made immediately (Fig. 6). The dolphins that are not suitable can be taken out of the net, passed over the top of the float line, and released.

Breakaway Hoopnet Technique

The breakaway hoopnet technique is best used on dolphins that engage in bow-riding behavior, and on smaller whales. This technique allows for only one specimen to be captured at a time. The dolphin or whale must be brought on board, and the hoopnet reset, before another capture attempt can be made.

For capturing dolphins, the person operating the hoopnet stands in a pulpit attached to the bow of the boat. In the live capture of small whales, the pulpit is attached to the end of a long plank similar to that used by swordfish fishermen (Fig. 7). In this technique, the object is to place the hoopnet in front of or over the head of the desired animal as it is surfacing to breathe (Fig. 8). The hoop should be of sufficient diameter to allow the species desired to pass through without hitting the edge of the ring, preventing injury (Fig. 9). The net is attached to the hoop with tape or thin string (Fig. 10). Any other material can be substituted if it is strong enough to hold the net on the hoop, but weak enough to break away when an animal passes through. The design of the breakaway hoopnet has been modified by some professional catchers and resembles a two-pronged pitch fork.

Once the desired animal has been snared or caught by the hoopnet, it is allowed to run and pull out additional line. It is not mandatory, but a float of some type could be attached to the line as a marker to aid the catcher in following the netted animal. It is then played like a fish on a line. It must not be allowed to have too much slack and at the same time must not be pulled in too fast. When the animal is alongside the boat, a sling or stretcher is worked into place and the dolphin is lifted aboard.

Hand and Rope Technique

The hand and rope technique is now used in the live capture of the white whale (*Delphinapterus leucas*); a species captured alive almost 100 yr ago (Lee 1878). The breakaway hoopnet and seine net techniques have also been used, but are not considered to be as efficient.

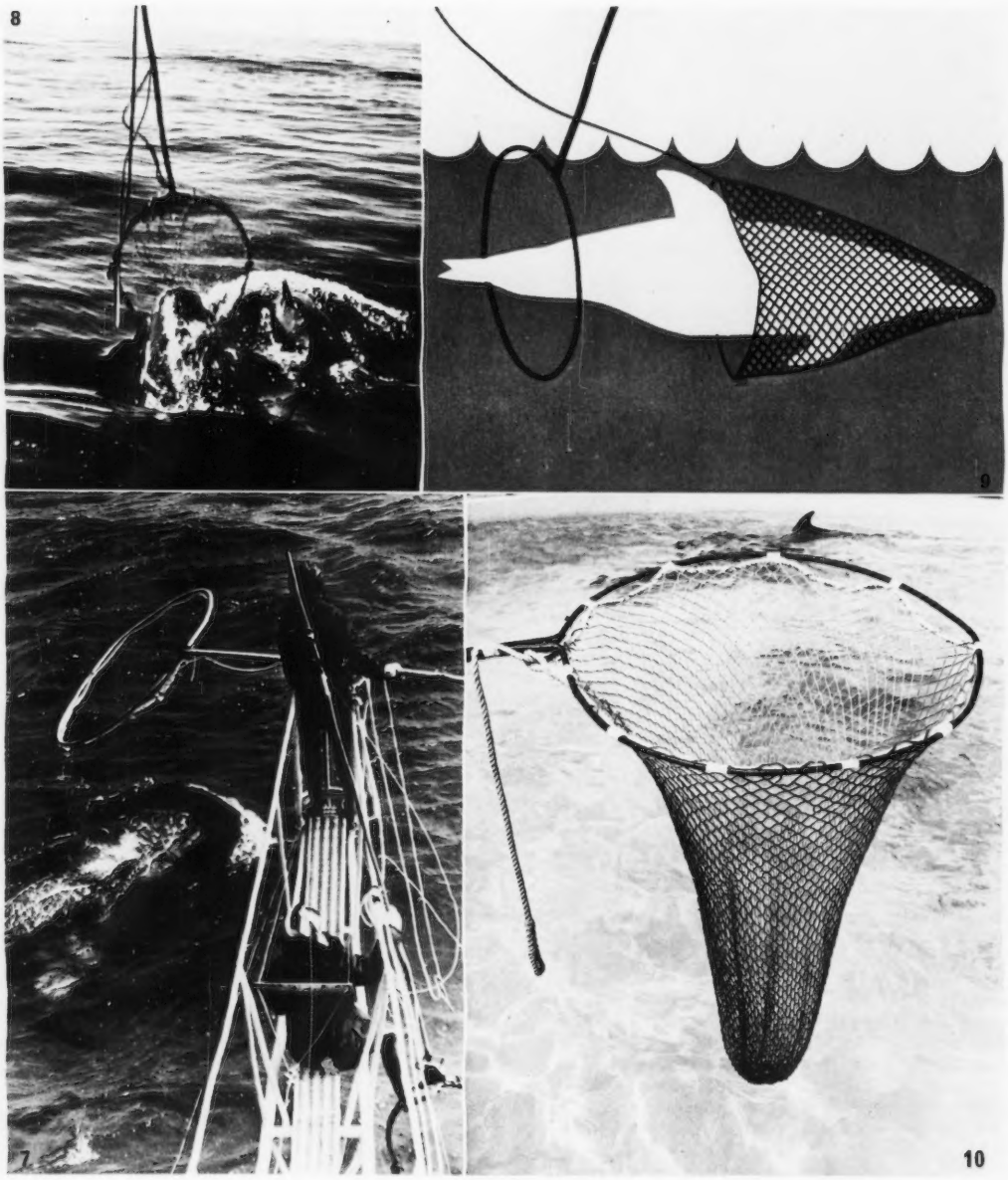
Small skiffs or canoes powered by outboard motors are used to herd the whales toward shallow water, approximately 4 ft in depth. The catcher takes position on the bow (Fig. 11) and when the whale is in the appropriate position, he will jump into the water alongside the whale and attempt to pass a soft rope over the head of the whale (Fig. 12). The rope is used as an extension of his arms to encircle the whale and hold it secure. Others then enter the water and secure the whale in a stretcher (Fig. 13). The whale is lifted aboard a towing boat for transportation to the holding facility (Fig. 14).

Selection of Animals

Every oceanarium, aquarium, and zoo undoubtedly has its own reasons for wanting certain species of smaller Cetacea and for that reason, each will have its own standards for selectivity.

I can relate only specific requirements that guide Sea World with its standards for selectivity. For every dolphin or whale collected, its use is predetermined. Sea World may require a certain number of the bottlenose dolphin, for example, for the express purpose of initiating a breeding program. This would require a particular balance of sexes and specific sizes. In view of the growth rate of this species, we would require males approximately 8 ft (2.4 m) in length and females from 7 to 7½ ft (2.1 to 2.3 m) in length. However, if our requirement was only to train the dolphin for a public show, we would collect younger or smaller animals 3–5 yr of age, from a minimum size of 5 ft, 8 inches (1.7 m) (yearling) to an approximate 6 ft, 6 inches (2 m).

Standards for selectivity will vary with the larger species, such as the killer whale (*Orcinus orca*) or white whale (*Delphinapterus leucas*) and the rule of thumb is to acquire specimens that would be considered subadult, or 1–4 or 5 yr of age. It is difficult to capture an adult killer whale (Griffin 1966) or white whale, and to handle them in the water, on boats, trucks, and airplanes to transport them to their final destinations. Also, large specimens are approaching the end of their natural life span, and thus is not a wise investment for an oceanarium. The younger animals



FIGURES 7–10. The breakaway hoopnet

FIG. 7. Bow plank extension and pulpit; the man in the pulpit is using a breakaway hoopnet device with a single rope loop. (Photo courtesy Sea World, Inc.); FIG. 8. Pilot whale (*Globicephala macrorhynchus*) entering the breakaway hoopnet. (Photo courtesy Sea World Inc.); FIG. 9. Illustrating the basic principle of the breakaway hoopnet. (Illustration, John Seeker.); FIG. 10. The breakaway hoopnet with bag attached to the ring with tape. (Photo by John Seeker.)

FIGURES 11–14. Capture of white whale (*Delphinapterus leucas*)

FIG. 11. Catcher perched on bow of canoe; FIG. 12. Successfully capturing a white whale; FIG. 13. Lifting the white whale aboard towing boat; FIG. 14. White whales being transported to holding facility. (Photos by John Seeker.)

seem to adapt to the change of environment with greater ease than do the older ones.

Mortality

Mortality might take place during the actual collection procedures, but more usually it occurs during the postcapture, acclimation period.

The postcapture acclimation period will vary, as do standards for selectivity, from one oceanarium, aquarium, or zoo to another. Once again, relating to Sea World standards, the postcapture acclimation period is 12 mo. During this period, mortality rates of 10–30% have been experienced. It is extremely difficult, if not at times impossible, to set up field examinations to foretell health problems with newly captured cetaceans. One has to assume that a healthy specimen has been captured.

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Review of the Live-Capture Fishery for Smaller Cetaceans Taken in Southern California Waters for Public Display, 1966–73[1]

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WALKER, W. A. 1975. Review of the live-capture fishery for smaller cetaceans taken in southern California waters for public display, 1966–73. J. Fish. Res. Board Can. 32: 1197–1211.

In a sample of 132 cetaceans taken during 1966–72 in a live-capture fishery for display at Marineland of the Pacific, mortality was low in *Tursiops* sp. (initially 10%, to over 50% within 24 mo, and high in *Delphinus delphis* (70% within 1 mo). Mortality within 1 mo and within 24 mo was under 20% and over 60%, respectively, for *Lagenorhynchus obliquidens*; and under 40% and over 60% for *Globicephala macrorhynchus*. Small numbers of *Lissodelphis borealis* and *Phocoenoides dalli* were also taken.

WALKER, W. A. 1975. Review of the live-capture fishery for smaller cetaceans taken in southern California waters for public display, 1966–73. J. Fish. Res. Board Can. 32: 1197–1211.

Dans un échantillon de 132 cétacés capturés à l'état vivant pour exposition au Marineland du Pacifique de 1966 à 1972, les mortalités de *Tursiops* sp. ont été faibles (10% au début à plus de 50% en dedans de 24 mois), et celles de *Delphinus delphis* ont été élevées (70% en dedans d'un mois). Les mortalités en dedans d'un mois et de 24 mois ont été au-dessous de 20% et au-dessus de 60% respectivement pour *Lagenorhynchus obliquidens*; et au-dessous de 40% et au-dessus de 60% pour *Globicephala macrorhynchus*. On a également capturé de petits nombres de *Lissodelphis borealis* et *Phocoenoides dalli*.

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THIS paper deals with some of the aspects of the capture, transport, handling, and acclimation to captivity of small cetaceans in the southern California area for Marineland of the Pacific in the 1966–72 period. Since its opening in 1954, Marineland of the Pacific, Palos Verdes Peninsula, California, has owned a 37-ft (11.3-m) collecting vessel and maintained a crew expressly for capturing local marine mammals and fish.

This study is oriented toward a greater general understanding of the problems involved in the capture and acclimation of six species of cetaceans. Actual mortality data presented represent a general overview of what occurred during the 1966–73 period. A thorough, systematic, detailed examination of possible variables in the captive environment that potentially may effect change in the mortality of cetaceans captured in the future is much needed. These studies should provide additional information to update clinical and husbandry techniques in order to lower captive mortality (see Ridgway 1972).

The data presented include only those for cetaceans taken for public display purposes; data on cetaceans captured for research, at-sea tagging activities, or transfer to other facilities for research are omitted. Data on selectivity, longevity, and mortality were taken from the author's personal records (extending from June 1968 to 1973), and Marineland's collecting, clinical, and mortality files for the period 1966 to June 1968.

The mortality data presented here represent only a general overview. Data on causes of death during various phases of acclimation would be useful, but the records are difficult to assemble into a meaningful pattern for discussion. Since the greatest mortality for all species concerned occurs in the first year of captivity, the data presented regarding longevity and mortality rates are analyzed only through a 2-yr period.

One hundred thirty-two cetaceans were captured for public display during the period 1966–72 by personnel of Marineland of the Pacific. None were taken during 1973 in compliance with the U.S. Marine Mammal Protection Act of 1972.

Four species of cetaceans have been routinely captured in southern California waters: common dolphin, *Delphinus delphis*; short-finned pilot

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whale, *Globicephala macrorhynchus*; Pacific white-sided dolphin, *Lagenorhynchus obliquidens*; and an offshore form of the Pacific bottlenose dolphin, *Tursiops* sp. The northern right whale dolphin, *Lissodelphis borealis*; and the Dall's porpoise, *Phocoenoides dalli*, were only occasionally taken. All species were taken near Santa Catalina and San Clemente Islands, and in the Catalina Channel area, off southern California.

All of the species were captured by a hoopnet or net snare technique identical to that described by Wood (1973). The net snare is composed of a break-away net mounted on a hoop device, which is placed over the animal's head as it surfaces in front of the collecting vessel. Once ensnared in the net, tension on the capture line purses the net just in front of the dorsal fin, and the net then engulfs the head and flippers. Cetaceans thus taken have full mobility of their flukes, and are able to respire normally prior to being maneuvered into position for lifting onto the collecting vessel (see Asper, this volume).

Species Accounts

Common Dolphin, *Delphinus delphis*

This small cetacean is the most delicate of the four routinely captured species discussed in this paper, and the most difficult to keep in captivity. The few that have survived the initial acclimation period performed only simple behavior during public shows.

Delphinus delphis is one of the most numerous year-round inhabitants of southern California waters. Animals for capture are typically selected from feeding or traveling schools. Feeding behavior of *Delphinus* is characterized by members of the school milling around over large areas in small groups, with no apparent uniform direction of movement. Often when engaged in feeding, this species is seen intermixed with groups of the abundant *Lagenorhynchus obliquidens*.

Assessment of the shape and social structure of traveling schools of *Delphinus* is extremely difficult to make from small vessels. Aerial surveys and observations from large vessels, where observers are located high off the water, give the best opportunity to examine the structure of dolphin schools. From the Marineland collecting vessel, traveling schools of *Delphinus* are easily spotted at considerable distances, since these animals — unlike *Lagenorhynchus* and *Lissodelphis* — greatly disturb the surface water as they travel. Traveling schools of *Delphinus* appear to be linear in shape, as described by Norris and Prescott (1961). Though traveling schools of *Delphinus* and *Lagenorhynchus* may be seen in close proximity, they do not typically intermix.

Around the collecting vessel, *Delphinus* readily engage in "bow-riding" behavior (Norris and Prescott 1961). Members of feeding and traveling schools will break off their activities and engage in this behavior for periods of 5 or 6 min.

This species is the most easily captured of all the smaller cetaceans frequenting California waters. When the school is sighted, the vessel is maneuvered so as to approach the school from behind, and the speed set to slightly overtake the animals. The vessel then runs through the center of the school traveling in the same direction. Under these conditions, the animals will run the bow for the greatest length of time. Bow-riding also takes place if the vessel approaches diagonally to the movement of a traveling school, but the animals soon break off and return to the original school. Collectors prefer to work traveling rather than feeding schools, as this affords them longer exposure time for capture attempts.

Capture of an animal initially disturbs other members of the same school, but apparently only for a brief time. (For example, as many as six members of a single school have been taken for research purposes in a 2-h period without unduly alarming the school.)

When comparing the available data on size ranges and sex, females (59%) seem to be taken more frequently than males (41%, see Table 1). This could be due to any or a combination of the following factors: 1) greater numerical abundance of females in schools of *Delphinus*; 2) selection by the collecting crew during capture; 3) selection by the vessel maneuvering into that portion of dolphin schools where females are more abundant. Of these three factors, the greater natural percentage of females to males is the most probable. Other workers who have had the opportunity to examine large samples of schools of other delphinids have reported much lower percentages of males to females (Kasuya 1972; Perrin 1969; Sergeant 1962; Carl 1945).

In *D. delphis*, the structure of the dolphin school in relation to the movement of the vessel would be a less determining factor in sex selectivity. This species is taken routinely from both feeding and traveling schools. Feeding schools, due to their apparent lack of organization, would offer a more random selection than would traveling schools.

Selection as to size of animal does occur. The collecting crew attempts to catch only those that appear free of scratches, abrasions, and lesions. Standard length of males taken ranged from 161 cm to 216 cm with a mean of 187 cm, and

TABLE 1. Summary of small cetaceans collected for public display, 1966–73.

Species	Total no. collected	Sample available for longevity data	Males			Females		
			No.	%	Mean length (*cm*)	No.	%	Mean length (*cm*)
Delphinus delphis	22	20	9	41	187	13	59	177
Globicephala macrorhynchus	33	27	11	33	317	22	67	340
Lagenorhynchus obliquidens	51	39	16	31	184	35	69	183
Lissodelphis borealis	2	2	2	100	209	–	–	–
Phocoenoides dalli	8	6	5	83	199	1	17	180
Tursiops sp.	18	18	6	33	272	12	67	260

of females, from 168 cm to 189 cm with a mean size of 177 cm (see Table 1). Harrison et al. (1969) recorded males of *D. delphis* as reaching sexual maturity at 187 cm to 198 cm with a mean of 192 cm, females at 173 cm to 193 cm with a 183 cm mean. It appears from their study that the sample captured ranged from immature to newly mature animals.

However, Evans (1974) recognized two populations or subpopulations of *Delphinus* from southern California waters, and since a considerable size range at sexual maturity may exist between these two populations, this conclusion should be regarded as tentative.

Once this cetacean is brought alongside the collecting vessel and its caudal peduncle restrained, it ceases to struggle. It is then lifted aboard the vessel, placed on foam pads, and covered with wet sheets. Water is applied throughout the period of transport to the oceanarium, which rarely exceeds 1½ h. Due to its psychological "fragility," this species is apparently stressed by capture. Nonetheless, none have been reported lost during capture.

Delphinus delphis usually arrives at the acclimation pool in an advanced state of shock. Upon introduction to the pool, a single, naive animal, left alone, quite often swims in an erratic fashion with low amplitude tail beats, occasionally bumping the walls. Contact with the walls of the acclimation pool typically causes the animal to cease swimming and sink to the bottom of the pool for periods of approximately thirty seconds before righting itself and returning to the surface to respire and continue swimming. If several naive animals are introduced into the acclimation pool at once, they typically do not utilize the entire available swimming area, but swim in tight circles together in the center of the tank. Sometimes they crowd each other so tightly that one or more begins to assume a head-up and tail-down position and sinks to the bottom of the pool where it remains for a short period before surfacing again. This behavior is similar to the fright-caused net-avoidance behavior described for *Stenella longirostris* in the eastern Pacific (Perrin and Hunter 1972). Though the immobilization and sinking behavior described usually ceases within 1 or 2 h, these animals still exhibit avoidance behavior of the pool walls and typically do not utilize the entire available swimming area for approximately 24 h, after which they settle into swimming patterns characteristic of captives.

Getting the animals to feed on dead fish is the most important step during the first and most difficult phase of the acclimation period. Whenever possible, it is desirable to introduce newly captured animals into an acclimation pool with one or more acclimated animals of the same species. In the past, this has greatly shortened the period of stress, and has promoted establishment of normal captive feeding patterns.

MORTALITY

A total of 22 *D. delphis* were captured for display purposes during the 1966–72 period (Table 2). None are alive at present. Of these, mortality data exist for 20 animals. Most mortality (75%) occurred during the first 60 days in captivity, with only 15% surviving more than 1 yr (see Fig. 1). Maximum survival was 2 yr, 7 mo.

In my opinion, the high mortality in this species was due primarily to stress, inanition, and inappetence; and secondarily to bacterial infections due to subsequent lowered resistance. Brown and Norris (1956) noted that if a newly captured *Lagenorhynchus obliquidens* refused to eat, it

TABLE 2. Chronological listing of *Delphinus delphis* captured between 1966 and 1973 for display purposes.

Date of capture	MLP Specimen no.	Sex	Standard length	Date of death
Jan. 28, 1966	66-17	Male	216 cm	unknown
Aug. 18, 1966	66-24-1	Female	183 cm	Dec. 6, 1966
Aug. 18, 1966	66-24-4	Female	171 cm	Sept. 7, 1966
Oct. 1, 1966	66-29-1	Male	161 cm	Oct. 29, 1966
Oct. 1, 1966	66-29-2	Female	175 cm	Nov. 1, 1968
Oct. 1, 1966	66-29-3	Female	173 cm	Oct. 28, 1966
Oct. 22, 1966	66-33	Male	unknown	Dec. 3, 1966
Nov. 3, 1966	66-35-1	Male	unknown	Apr. 4, 1969
Nov. 3, 1966	66-35-2	Female	unknown	June 13, 1969
Oct. 4, 1967	67-24	Female	unknown	Oct. 17, 1967
Oct. 21, 1967	67-32-1	Male	unknown	Oct. 21, 1967
Mar. 21, 1968	68-4	Female	unknown	unknown
Oct. 16, 1968	68-26-1	Female	174 cm	Apr. 18, 1969
Aug. 11, 1969	69-32-1	Female	189 cm	Aug. 27, 1969
Aug. 11, 1969	69-32-2	Female	168 cm	Aug. 18, 1969
Aug. 11, 1969	69-32-3	Female	180 cm	Aug. 31, 1969
Aug. 11, 1969	69-32-4	Female	181 cm	Aug. 23, 1969
Aug. 12, 1969	69-33-1	Male	178 cm	Sept. 5, 1969
Aug. 12, 1969	69-33-2	Male	192 cm	Aug. 27, 1969
May 19, 1970	70-10-1	Male	unknown	May 30, 1970
May 19, 1970	70-10-2	Female	unknown	May 30, 1970
May 19, 1970	70-10-3	Male	unknown	May 30, 1970

would die from starvation within 7–10 days. This is true for *D. delphis* as well. Signs of weight loss can be detected in inappetent *Delphinus* within 4 days after capture. Initial weight loss also appears to be caused by stress as well as inappetence, as even animals that began feeding on a full complement of food a matter of hours after capture exhibited some signs of weight loss for a brief period before that weight was regained.

Gastric ulcers, recorded by Brown and Norris (1956), have been implicated as causes of death in newly captured *Delphinus*. Additional necropsy examinations of six *Delphinus* taken in August of 1969 for public display revealed numerous sharp-edged ulcerations extending from the forestomach up through the esophagus to the base of the tongue. The probable etiological agent was stress.

Incidence of Naturally Occurring Disease

The incidence of naturally occurring parasitism was minimal. The sample appeared to be essentially free of debilitating parasites, such as trematode infections of the air sinuses and pancreas commonly seen in beach stranded *Delphinus* in the southern California area (Schroeder et al. 1973). Lungworms were also absent. The encysted larval cestodes *Monorygma* sp. and *Phyllobothrium* sp. were commonly seen in the peritoneal cavity and blubber, respectively, but did not appear to bear any pathological significance.

Pacific White-Sided Dolphin, *Lagenorhynchus obliquidens*

The Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, is a common year-round inhabitant of southern California waters. Pronounced seasonal movements of this species have been reported and related to seasonal variations in the preferred prey species, e.g.: anchovy (*Engraulis mordax*) and squid (*Loligo opalescens*; see Brown and Norris 1956). Norris and Prescott (1961) reported that *L. obliquidens* is common in inshore waters during winter and spring, and is found in offshore waters around the outer Channel Islands during summer and fall. Schools of an estimated 1000 animals have been observed scattered over an area of 4 square miles (Brown and Norris 1956).

Observations of schooling behavior are described in Brown and Norris (1956), Norris and Prescott (1961), and Brownell (1964). *Lagenorhynchus obliquidens* is observed to intermix with a variety of other cetaceans, including: *Balaenoptera borealis*, *Megaptera novaeangliae*, *Phocoenoides dalli* (in central California, Brownell 1964), *Globicephala macrorhynchus*, *Delphinus delphis*, and *Tursiops gilli* (Norris and Prescott 1961).

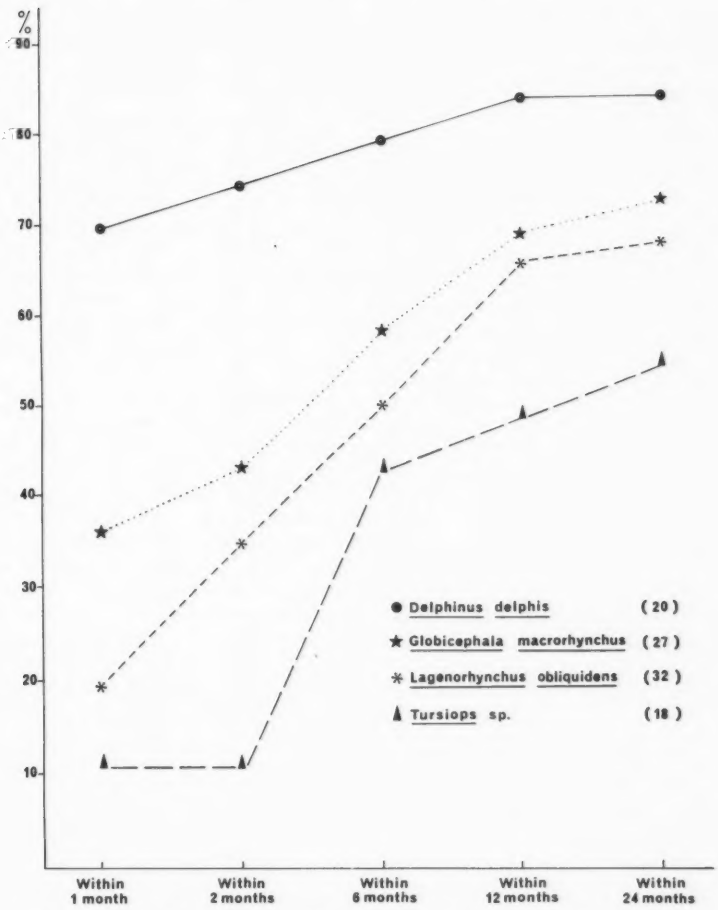

FIG. 1. Mortality of newly captured cetaceans collected between 1966–72. Sample size for each species in parentheses. Longevity data carried through 1973, but no animals collected in that year.

Schools of *L. obliquidens* are more difficult to spot at a distance from the collecting vessel than are those of *D. delphis*. Typically, schools of *Lagenorhynchus* do not disturb the surface to the degree that those of *Delphinus* do. Collectors report that at a distance, the gray-black dorsal fins of this species quite often appear like sea birds floating on the surface. Frequently during searches for this species, it will suddenly appear at the bow of the collecting vessel without the collecting crew noticing it in the area beforehand. Generally, *Lagenorhynchus* is less inclined to bow-ride than *Delphinus*, particularly when engaged in feeding activity. When individuals from feeding schools come to the bow of the vessel, they typically bow-ride for a very brief period, then suddenly dart off and resume their previous activity. Feeding groups of *L. obliquidens* are not productive for collectors.

On the other hand, traveling schools are easily approached. The techniques of approach are similar to those practiced on *D. delphis*, with the vessel coming up from the rear and slowly overtaking the school. Under these conditions, the individual animals readily bow-ride, although for a shorter period of time than *D. delphis*.

This species has been reported to demonstrate cooperative, attentive behavior when members of the school are captured. Brown and Norris (1956) reported a number of individuals of a school

swimming about a tethered animal in attentive fashion, departing to rejoin the school only when the newly captive animal was lifted out of the water. Norris and Prescott (1961) also reported observing similar behavior. This behavior has not been observed for *D. delphis*.

Fewer males (31%) were collected than females (69%; see Table 1). This percentage difference is considerably greater than that for *D. delphis*. The sample size of *L. obliquidens* available for study was twice that of *D. delphis*.

The greater number of females taken might indicate a naturally greater percentage of females in the age-groups selected for capture. Since *Lagenorhynchus* are captured almost exclusively from traveling schools, selectivity may be imposed by the vessel working a particular portion of the dolphin school in which females are more abundant.

Conscious selection on the part of the collectors involved does occur. As with *Delphinus delphis*, they select for what they refer to as "clean" animals, i.e. free from excessive scratches, skin lesions, etc. It is evident from examination of records that a rather specific age-group of both sexes is taken as a result of this selectivity. Standard length of females taken ranged from 167 to 197 cm with a mean size of 183 cm. Males ranged from 177 to 195 cm with a mean of 184 cm. Harrison et al. (1969) recorded reproductively mature males of this species as ranging between 170 and 180 cm. The smallest reproductively mature female recorded was 173 cm.

Once the animal is netted and brought alongside the vessel with its caudal peduncle restrained, it ceases to struggle and is lifted aboard. It is placed on foam pads, covered with sheets, and kept continually wet during transport to the oceanarium. Although *Lagenorhynchus* is typically taken farther offshore than *Delphinus*, the transport time rarely exceeds 3 h.

This species does not appear to be stressed by capture and transport to the degree observed in *D. delphis*. After introduction to the acclimation pool, individuals and groups of naive animals will swim primarily in the center of the tank, avoiding the walls. The fright-immobilization behavior typical of newly captured *D. delphis* is rarely observed in *L. obliquidens*. The period of time during which these animals exhibit extreme fright when introduced into the acclimation pool is considerably shorter than that observed for *D. delphis*.

As with *Delphinus delphis*, introduction of newly captured *L. obliquidens* into pools containing acclimated members of the same species typically shortens the initial stress period and promotes early establishment of artificial feeding patterns.

Mortality

A total of 51 *L. obliquidens* were taken for public display purposes during the 1966–72 period (Table 3). Of the 51 animals, 10 remain alive in captivity at the time of this writing (March 1974): five at Marineland of the Pacific, Palos Verdes Peninsula, California; three at Steinhart Aquarium, San Francisco, California; one at New York Aquarium, Coney Island, N.Y.; and one at Vancouver Public Aquarium, Vancouver, B.C., Canada. Of these 51 animals, complete longevity data exist for 39.

Examination of the mortality rate (see Fig. 1) reveals considerably better survival than that for *D. delphis*. Fifty percent of the *L. obliquidens* taken were lost within the first 6 mo of captivity. By the end of the first year, the mortality reached a peak of 67%, and then began to level off. Examination of longevity data reveals that cetaceans of this species surviving beyond 1 yr in captivity are fully acclimated and have an excellent chance of surviving at least 2 yr without incident. At present, the average captive age for the 10 living *L. obliquidens* surviving beyond 1 yr in captivity is approximately 5 yr. Five of these 10 animals have lived in captivity over 8 yr.

Incidence of Naturally Occurring Disease

Evidence of naturally occurring disease in *L. obliquidens* taken during this period is slight. Debilitating parasitic infections such as those caused by lungworm and liver, pancreas, and air sinus trematode flukes have not been implicated in the captive mortality; however, blood records indicate the presence of active disease processes in at least two animals of this species upon arrival at the oceanarium. These two cetaceans had a total white blood cell count in excess of 15,000/mm^3 on arrival. Both these individuals manifested chronic illness throughout their captive existence, but the specific causes of the diseases were not determined.

Pacific Bottlenose Dolphin, *Tursiops* sp.

This offshore form of *Tursiops* was reported (Norris and Prescott 1961) to be the same species (*T. gilli*) as that inhabiting the inshore waters of southern California and the Pacific coast of Baja California, as well as the inshore waters of the Gulf of California. On the basis of comparisons of feeding habits, behavior, and preliminary

TABLE 3. Chronological listing of *Lagenorhynchus obliquidens* captured between 1966 and 1973 for display purposes.

Date of capture	MLP Specimen no.	Sex	Standard length	Date of death
Mar. 24, 1966	21	Female	unknown	[a]
Mar. 25, 1966	17	Female	unknown	[a]
May 19, 1966	66-10	Male	181 cm	Jan. 20, 1969
Nov. 4, 1966	66-36-1	Male	unknown	unknown
Nov. 4, 1966	66-36-2	Female	unknown	[a]
Nov. 15, 1966	66-38-1	Female	180 cm	[a]
Nov. 15, 1966	66-38-2	Female	180 cm	[a]
May 16, 1967	67-13	Female	unknown	May 30, 1967
May 18, 1967	67-14-1	Male	188 cm	June 5, 1967
May 18, 1967	67-14-2	Male	177 cm	June 12, 1967
Oct. 3, 1967	67-23-1	Female	167 cm	Feb. 28, 1968
Oct. 3, 1967	67-23-2	Female	190 cm	Nov. 7, 1967
Oct. 3, 1967	67-23-3	Female	190 cm	Nov. 7, 1967
Oct. 20, 1967	67-24	Male	185 cm	unknown
Oct. 11, 1967	67-26	Male	188 cm	Dec. 9, 1967
Oct. 13, 1967	67-30	Female	unknown	unknown
Oct. 20, 1967	67-29	Male	185 cm	unknown
Feb. 26, 1969	69-6-1	Female	unknown	Jan. 21, 1970
Feb. 26, 1969	69-6-2	Female	unknown	Apr. 14, 1969
Feb. 27, 1969	69-7-2	Female	unknown	unknown
Feb. 27, 1969	69-7-3	Female	unknown	May 30, 1969
Feb. 27, 1969	69-7-4	Female	unknown	unknown
July 10, 1969	WAW 81[b]	Male	180 cm	Aug. 3, 1969
July 21, 1969	WAW 84[b]	Female	174 cm	Sept. 16, 1969
Nov. 4, 1969	69-11	Male	unknown	June 19, 1970
Oct. 28, 1969	69-39	Female	181 cm	[a]
Oct. 28, 1969	69-40	Female	184 cm	unknown
Oct. 28, 1969	69-41	Female	184 cm	Nov. 7, 1969
Oct. 28, 1969	69-42	Female	189 cm	Apr. 26, 1970
Dec. 8, 1969	69-43	Male	180 cm	Sept. 14, 1970
May 6, 1970	70-9	Female	172 cm	Apr. 22, 1971
Sept. 22, 1970	70-19-1	Female	182 cm	June 26, 1973
Sept. 22, 1970	70-19-2	Female	unknown	unknown
Sept. 27, 1970	70-20	Female	unknown	Mar. 20, 1972
Oct. 15, 1970	70-21-1	Female	unknown	[a]
Oct. 15, 1970	70-21-2	Female	unknown	unknown
Oct. 20, 1970	70-22-1	Female	182 cm	May 15, 1971
Oct. 20, 1970	70-22-2	Female	197 cm	Nov. 7, 1970
Oct. 21, 1970	70-23	Female	195 cm	Mar. 24, 1971
Oct. 26, 1970	70-24-1	Male	unknown	unknown
Oct. 26, 1970	70-24-2	Female	185 cm	Nov. 9, 1970
Nov. 27, 1970	70-27	Female	186 cm	Nov. 27, 1970
Feb. 9, 1971	71-3-1	Male	unknown	unknown
Feb. 9, 1971	71-3-2	Female	unknown	Mar. 27, 1971
Nov. 23, 1971	71-11-1	Female	unknown	July, 4, 1972
Nov. 23, 1971	71-11-2	Male	195 cm	Feb. 1, 1972
Jan. 19, 1972	72-4	Male	unknown	[a]
Feb. 23, 1972	72-6	Male	unknown	May 26, 1972
Feb. 23, 1972	72-7	Male	unknown	[a]
Feb. 24, 1972	72-8	Female	unknown	[a]
Feb. 25, 1972	72-9-2	Female	unknown	unknown

[a]Still living as of Mar. 1, 1974.
[b]Denotes field numbers of author.

cranial measurements, I think that the offshore and inshore populations may be distinct.

In southern California, small schools of this cetacean are typically seen accompanying schools of *Globicephala macrorhynchus*, usually broken up into small subgroups of 5–10 animals located on the outer fringes of the school. Because of their location on the peripheral areas of the pilot whale schools, the sighting of *Tursiops* is used by collectors as an index of pilot whale occurrence.

At least the offshore form of *Tursiops* readily bow-rides, though the animals are noticeably more wary and watchful of human activities on the vessel when bow-riding than are *Lagenorhynchus* and *Delphinus*. Once they have noted the position of the collector in the bow pulpit, they frequently engage in lengthy bow-riding, but surface for air off to the side of the bow just out of reach of the net snare, and then return to continue bow-riding (B. Falcone personal communication 1974). Occasionally, entire groups of bow-riding *Tursiops* suddenly disappear from the bow and play in the stern wake. Then the vessel is set in a tight circle, and once the animals have resumed bow-riding, the vessel is then pointed in the same direction as the school from which they came.

The ratio of females (67%) and males taken is similar to that of other cetaceans captured in this fishery (see Table 1). This probably reflects a naturally greater ratio of females to males in the population; however, other possible factors such as the social organization of schools of *Tursiops* and selection of age-groups may contribute and cannot be ruled out.

As with *Lagenorhynchus* and *Delphinus*, the collection crew primarily select for clean animals, free from excessive scratches and skin lesions. Examination of the available size data (Table 1, 4) reveals a size range of females from 238 to 290 cm with a mean of 260 cm. Males taken range from 231 to 323 cm with a mean of 272 cm. Little is known of the relative size of males and females at sexual maturity. Reproductive data published (Harrison et al. 1969) include data on ovaries from two females taken in the offshore Santa Catalina Island area. The largest female (263 cm) was reported to be probably nearing sexual maturity. No reproductive tissues from males in this area have been examined.

The size ranges for both males and females indicate a greater size range for both sexes than is seen in *Lagenorhynchus* and *Delphinus*. *Tursiops* is generally not as abundant as *Lagenorhynchus* and *Delphinus*, and typically occurs in small groups of not more than 10 animals. The greater size range probably reflects a less selective attitude on the part of the collectors since there are fewer animals available for capture.

As has been observed in the capture of *Lagenorhynchus* and *Delphinus*, this form of *Tursiops*, when brought alongside the collecting vessel, ceases to struggle once the flukes and tail stock are restrained. The animal is then lifted aboard by stretcher. Techniques utilized during transport are similar to those for other species taken. Transport time to the oceanarium rarely exceeds 3 h.

Behavior of this species when introduced into the acclimation pool is uneventful; they appear calm and are not prone to bump the walls of the enclosure. When crowded by adjacent walls or other animals, newly captured *Tursiops* will occasionally sink and lie on the bottom for a few moments prior to resuming a swimming pattern. These animals are also like local *Globicephala* (see below) in that they appear greatly distressed when placed in shallow, 6-ft deep pools. Like pilot whales, they are prone to drift about on the surface for extended periods. As with the other species of cetaceans, introduction to the acclimation pool with another acclimated member of the same species shortens the period of adjustment considerably.

Tursiops typically initiate feeding within 2 days after capture. Refusal to feed in the first 5 days after capture has not been observed for this cetacean.

Mortality

Mortality during initial live capture attempts does occur for this species. Records of the number of animals lost during capture are not available, but losses have been estimated to be as high as two out of five animals taken. When on board the collecting vessel, this cetacean is prone to regurgitate its stomach contents. Some of the animals have suffocated due to occlusion of the respiratory passageways with regurgitated food (typically squid).

Once in captivity, this species has proven to be the most adaptable of all cetaceans taken in this fishery. Longevity data are available for all 18 animals taken during this period (Table 4). Few animals are lost during the first 60 days in captivity (see Fig. 1). Figure 1 indicates a sharp increase in mortality to 50% by the end of 1 yr; however, examination of available necropsy data reveals that three of the 18 *Tursiops* sp. taken succumbed in less than 1 yr to causes other than disease. Two died of what may be termed accidental deaths in which complications arising from

TABLE 4. Chronological listing of *Tursiops* sp. captured between 1966 and 1973 for display purposes.

Date of capture	MLP Specimen no.	Sex	Standard length	Date of death
Nov. 8, 1966	66-37	Male	263 cm	Nov. 29, 1971
Nov. 17, 1966	66-39	Female	276 cm	Sept. 20, 1971
June 15, 1967	67-15	Female	257 cm	Sept. 15, 1967
Aug. 5, 1969	69-31	Male	267 cm	[a]
Oct. 16, 1969	69-36	Female	unknown	[a]
Oct. 20, 1969	69-37	Female	256 cm	Mar. 12, 1970
Oct. 21, 1969	69-38	Male	277 cm	Aug. 7, 1970
Nov. 20, 1970	70-26	Female	unknown	[a]
Dec. 3, 1970	70-28	Female	251 cm	[a]
Jan. 5, 1971	71-1	Female	unknown	[a]
Feb. 5, 1971	71-2	Male	231 cm	Apr. 7, 1971
Feb. 9, 1971	71-3-3	Female	290 cm	Feb. 26, 1971
May 20, 1971	71-5	Female	255 cm	Nov. 16, 1971
June 28, 1971	71-6	Female	unknown	Sept. 1971
Jan. 12, 1972	72-2	Female	unknown	[a]
Jan. 14, 1972	72-3	Male	323 cm	Apr. 17, 1972
Apr. 20, 1972	72-15	Female	238 cm	Jan. 4, 1974
Nov. 9, 1972	72-17	Male	unknown	Nov. 29, 1972

[a]Still living as of Mar. 1, 1974.

foreign body ingestion (plastic bags, plant clippings, etc.) were directly implicated. Another, an immature male, apparently died from stress and wounds inflicted by the aggressive attention of two mature male *Tursiops truncatus*. The prevention of the circumstances of these accidental deaths would have presumably lowered the mortality at the end of the 1-yr period, from 50% to approximately 33%. At present, five of the 18 *Tursiops* sp. taken during this period remain alive in captivity at Marineland of the Pacific. To date, the longest survival period for this species in captivity is 5 yr.

INCIDENCE OF NATURALLY OCCURRING PARASITISM

Naturally occurring parasites are evident for this species, but do not appear to influence mortality to any major extent. Lungworm (*Halocerus* sp.) has been observed fairly frequently, but infections appear to be light and are not involved with extensive tissue pathology. One animal arrived at the oceanarium with a total white blood cell count of 18,400/mm^3 and was chronically ill for the entire month prior to death. Necropsy revealed a heavy infection of the nematode parasite *Crassicauda* sp. in the right air sinus. Necrotic erosion of the ventral surface of the frontal bone was evident, and similar to that described for *Stenella attenuata graffmani* in the eastern tropical Pacific (Dailey and Perrin 1973).

Northern Right Whale Dolphin, *Lissodelphis borealis*

This small, finless cetacean is infrequently observed in the Channel Island area (Norris and Prescott 1961, reported only six sightings). Collecting vessel observations and captures of this species were made primarily during February through May.

The absence of a dorsal fin and the slight water surface disturbance created by this species make schools of *L. borealis* extremely difficult to sight at the low level of the collecting vessel. Quite often, the collectors' attention is attracted by the reflections of light that flashed off the animals' backs as they surface.

When approached, schools of *L. borealis* are prone to take flight, scatter, and regroup a considerable distance away from the vessel. This flight pattern includes animals clearing the water with a series of regular, low-angle leaps (Norris and Prescott 1961) and illustrated in Leatherwood et al. (1972).

Lissodelphis borealis has demonstrated little tendency to bow-ride the collecting vessel. Bow-riding has occurred primarily when these animals are in the company of *Lagenorhynchus obliquidens*. The only two specimens of *L. borealis* captured were taken by the net-snare while the animals were bow-riding with members of a school of *L. obliquidens*.

TABLE 5. Chronological listing of *Phocoenoides dalli* and *Lissodelphis borealis* captured between 1966 and 1973 for display purposes.

Date of capture	MLP Specimen no.	Sex	Standard length	Date of death
		Phocoenoides dalli		
Feb. 29, 1972	72-10	Male	176 cm	Apr. 28, 1972
Mar. 2, 1972	72-11	Male	203 cm	May 21, 1972
Mar. 8, 1972	72-12	Male	204 cm	Mar. 13, 1972
Mar. 21, 1972	72-13	Male	210 cm	June 26, 1973
		Lissodelphis borealis		
Feb. 27, 1969	69-7-1	Male	217 cm	Mar. 1, 1969
Feb. 25, 1972	72-9-1	Male	200 cm	May 18, 1973

The behavior of these animals during capture was unique compared to that of the other species. In each instance, the animal became completely immobile on the surface the instant the net-snare was pursed around the head and flippers (B. Falcone personal communication 1974).

The behavior of the two captured *L. borealis* (Table 5), upon introduction to the acclimation pool, differed considerably. The first animal, a 217-cm immature male captured February 27, 1969, was placed in a 20,000-gal circular holding pool with four acclimated *L. obliquidens*. Upon release from the transport stretcher, the newly captured animal joined up with the four *Lagenorhynchus* after a short delay. All five animals schooled up and swam at exceptional rates for unusually extended periods of time. This animal was found dead in the pool 3 days later. Gross necropsy and histopathological findings were commensurate with those typical of stress (J. Simpson, D.V.M., Marineland communications, 1969).

The second specimen of this species, an approximately 200-cm immature male taken on February 25, 1972, was placed in the same acclimation pool with three acclimated *Lagenorhynchus obliquidens*. After several low velocity contacts with the enclosure walls, this specimen of *L. borealis* joined up with the three white-sided dolphins in an apparently calm, uniform swimming pattern. This animal began feeding the following day. Three months later, it was moved to a 540,000-gal display tank with a male *Phocoenoides dalli*. The second specimen of *L. borealis* lived in captivity for 15 mo. Cause of death was undetermined (but see below).

INCIDENCE OF NATURALLY OCCURRING PARASITES

The second animal, captured February 25, 1972, was found at necropsy to have a bilateral infection of the air sinus fluke, *Nasitrema* sp. Considerable ulceration and abscessation of the epithelial lining of the air sinus complex was noted. These lesions may have been severe enough to be a contributing factor in the death of this animal.

Short Finned Pilot Whale, *Globicephala macrorhynchus*

The first pilot whale collected alive at sea for public display was taken in 1957 (Brown 1960). Since then, these animals have been popularized and have been trained to demonstrate complex behavior for public entertainment (Gilmore 1962).

Norris and Prescott (1961) reported the Pacific pilot whale as being present in southern Californian waters throughout the year, and becoming particularly abundant during the squid spawning season which occurs in the winter months.

One specific group of pilot whales, a school of 20–30 animals, is seen throughout the Catalina Channel area year-round, as well as in the vicinity of Catalina, San Clemente, and Santa Barbara Islands. Individuals of this resident school, recognized by their numerous distinctive scars, have also been observed off the Huntington Beach area and the Palos Verdes Peninsula. One large animal in particular, whose entire dorsal fin was possibly blown off by buckshot, has been observed in this uniquely scarred school for 6 yr (B. Falcone personal communication 1974). This resident group is especially boat-shy, and the collectors avoid attempting to work it whenever possible.

Schooling activity of pilot whales in these waters (Norris and Prescott 1961) includes the behavior described by Norris (1958) as the "loafing group." Large groups of this species lie at the surface in stationary aggregations, blowholes and anterior portion of the back exposed above the

FIG. 2. Collector in position on bow extension of *Geronimo* as vessel maneuvers into position for capture of the short-finned pilot whale, *Globicephala macrorhynchus*. This type of bow extension is utilized exclusively in the collection of this species. (Photograph by J. Prescott)

water. On occasion, members of groups participating in this activity appeared as if they were sleeping. They have been closely approached by the collecting vessel, and almost run over before they appeared to awake with a start and quickly sound. Some of the animals captured for public display have been taken out of schools exhibiting this behavior. The hoop and net was placed over the animal's head, seemingly before the animal was aware of the vessel's presence. Collectors also report that once a group of animals exhibiting this behavior has been startled, it is extremely difficult to approach with a vessel for the rest of the day (B. Falcone personal communication 1972).

Pilot whales are the most difficult to capture of any of the cetaceans covered in this paper, the primary reason being that they do not bow-ride. The collecting vessel must be equipped with an extension on the bow similar to those utilized in the swordfish fishery. The collector rides on this extension with a hoop fitted with a break-away net similar in construction to that used for capture of small dolphins (Fig. 2).

Schools of pilot whales are easily disturbed. Basically, the collecting technique involves positioning the collector on the bow extension over a particular member of the school selected for capture. A miss with the hoopnet or sudden change in the vessel's engine speed can cost hours in getting back into position with a particular school. Five or 6 h spent working a select group of animals without result is not unusual. On one occasion, the collectors worked for 21 days, sighting pilot whales every day before a successful capture.

Once netted and brought alongside the vessel, the animal is worked into a stretcher which is then lifted aboard and placed on foam pads. The whale is typically in an upright position throughout transport, which rarely exceeds 3 h.

The behavior typical of newly captured pilot whales when placed in the acclimation pools differs with the age of the animal. Small animals, approximately 9–10 ft (274–305 cm) in length, are more prone to panic. Pilot whales of this size are known to make high speed runs at the walls of the enclosure unless they are placed in a pool containing an acclimated pilot whale for company. Older pilot whales, ranging between 11 and 14 ft

(335–426 cm) in length appear calmer. When introduced into the acclimation pool, they typically spend several hours floating on the surface prior to resuming normal swimming patterns. Regardless of size, in less than ideal situations where a newly captured member of this species must be placed alone in the pool, it is advisable initially to lower the water level to restrict temporarily the animal's movements and prevent potential injury from high speed contacts with the enclosure walls.

Shallow pools (approx. 6 ft [2 m] deep) are not sufficient for acclimating this species of cetacean. Under these conditions, the animals appear depressed and spend extended periods floating on the surface; they are extremely difficult to get into normal captive feeding patterns.

Comparison of available data on pilot whales captured during this period also indicates a rather pronounced difference in the ratio of females (67%) to males (33%; see Table 1). The sex ratio of pilot whales may be skewed, as, depending on display requirements, instructions to collectors might sometimes have been to release all males caught. These percentages for *Globicephala macrorhynchus* closely agree with the findings of Sergeant (1962) for herd composition for *G. melaena*, in which all postnatal animals examined included 39.5% males. Because *G. macrorhynchus* does not bow-ride and has to be taken by a highly selective hunting procedure, herd social structure and size selection may also be involved.

Pilot whales are selected for capture on the basis of two criteria: size and external appearance. As with *L. obliquidens* and *D. delphis*, clean appearing animals are selected for during capture attempts; however, the size of the animal is the main factor considered in the conscious selection on the part of the collectors. Past experience has indicated that pilot whales under 9 ft (274 cm) in length are too young for captive purposes, for they have not adapted well to captivity. Pilot whales larger than 15 ft (457 cm) in length are considered too large for the lifting capacity of the collecting vessel (a 15-ft pilot whale would weigh approximately 2000 lb). The optimum size for transport and acclimation purposes is considered to be between 10 and 15 ft, (305–457 cm). Taking of females over 12 ft (366 cm) in length, however, increases the probability of capturing pregnant females. Harrison et al. (1972) reported some females of this length to be sexually mature. Size ranges for *G. macrorhynchus* females taken during this survey period ranged from 8 ft 1 inch (246 cm) to 15 ft 9 inches (480 cm) with a mean of 11 ft 2 inches (340 cm). Only one pregnant female (13 ft = 396 cm, taken in November of 1970) was recorded. Males ranged from 9 ft 1 inch (277 cm) to 12 ft 3 inches (373 cm) with a mean of 10 ft 5 inches (317 cm) and were all reproductively immature.

The size range at which males of this species become reproductively mature is not clear, although using the size ranges of *G. melaena* in the Atlantic (Sergeant 1962), males are reproductively mature at 490 cm (16 ft).

Mortality

At the time of this writing (March 1974), 5 of the 33 Pacific pilot whales taken during the 1966–72 period remain alive in captivity: one at ABC Marineworld, Redwood City, Calif.; one at Marineland of Florida, St. Augustine, Fla.; and three at Marineland of the Pacific, Palos Verdes Peninsula, Calif. To date, the average captive longevity for these five pilot whales is 3½ yr; maximum longevity is 7 yr (Table 6).

Of the 33 pilot whales captured for public display, longevity data are available for 27. Mortality of this species in captivity is relatively high when compared with that of other species of cetaceans involved in this fishery (see Fig. 1). Thirty-five percent mortality is reached within 30 days after capture. During the first 2 yr in captivity, the mortality steadily increases until it reaches 74%.

Incidence of Naturally Occurring Parasitism

Naturally occurring parasitic infestations such as lungworm or the occurrence of air sinus and pancreatic trematode infections have not been observed in the captive pilot whales discussed. Larval phyllobothriid (Cestoda) cysts, *Monorygma* sp., and *Phyllobothrium* sp., are frequently observed during necropsy, but have not been implicated in captive mortality.

Dall's Porpoise, *Phocoenoides dalli*

This is the only phocoenid taken in this fishery. It is seen infrequently in the Catalina Channel area throughout the year, but becomes more abundant during the winter and spring months, particularly December through April.

In the Catalina Channel area, these cetaceans are typically encountered in small groups of 5–10 individuals milling about in a random fashion over a relatively small area, presumed to be engaged in feeding. Dall's porpoise is assumed to be one of the swiftest and most powerful of the small cetaceans encountered in this area (Norris and Prescott 1961; Brownell 1964).

TABLE 6. Chronological listing of *Globicephala macrorhynchus* captured between 1966 and 1973 for display purposes.

Date of capture	MLP Specimen no.	Sex	Standard length	Date of death
Aug. 31, 1966	66-25	Male	287 cm	Oct. 6, 1966
Sept. 6, 1966	66-26	Female	358 cm	[a]
Sept. 7, 1966	66-27	Female	320 cm	July 1973
Nov. 21, 1966	66-40	Female	340 cm	unknown
Nov. 23, 1966	66-41	Female	292 cm	Dec. 15, 1966
Mar. 28, 1967	67-11	Female	366 cm	June 27, 1967
June 27, 1967	67-16	Female	246 cm	Jan. 31, 1968
June 28, 1967	67-17	Female	480 cm	July 9, 1967
Mar. 4, 1968	68-2	Female	381 cm	Oct. 7, 1968
Mar. 11, 1968	68-3	Female	320 cm	May 28, 1971
May 6, 1969	69-16	Male	290 cm	Oct. 24, 1969
May 21, 1969	69-21	Male	277 cm	unknown
May 9, 1969	69-22	Female	259 cm	unknown
May 29, 1969	69-23	Female	unknown	unknown
June 2, 1969	69-24	Male	325 cm	[a]
Sept. 17, 1969	69-34	Male	373 cm	Feb. 5, 1971
Oct. 8, 1969	69–35	Female	457 cm	Jan. 19, 1970
Jan. 7, 1970	70-1	Female	310 cm	Jan. 13, 1970
Jan. 18, 1970	70-2	Male	348 cm	Feb. 1, 1970
Jan. 22, 1970	70-3	Male	320 cm	Feb. 10, 1970
Jan. 23, 1970	70-4	Male	325 cm	Feb. 12, 1970
Jan. 29, 1970	70-5	Male	unknown	Feb. 15, 1970
Feb. 6, 1970	70-7	Female	320 cm	Feb. 12, 1970
Nov. 3, 1970	70-25	Female	396 cm	[a]
Dec. 11, 1970	70-30	Male	305 cm	unknown
Nov. 10, 1971	71-9	Female	315 cm	unknown
Nov. 11, 1971	71-10	Female	326 cm	Jan. 2, 1972
Feb. 2, 1972	72-5	Female	330 cm	Feb. 8, 1972
Nov. 21, 1972	72-19	Female	320 cm	Dec. 8, 1972
Nov. 30, 1972	72-20	Female	305 cm	[a]
Dec. 1, 1972	72-21	Female	351 cm	July 24, 1973
Dec. 12, 1972	72-22	Male	unknown	[a]
Dec. 15, 1972	72-23	Female	unknown	Feb. 18, 1973

[a]Still living as of March 1, 1974.

This species does not readily ride the bow of the collecting vessel, which has a maximum speed of about 8 knots. The technique for capture is to locate these small groups of Dall's porpoise and manoeuver the vessel in a series of tight circles around the group. Members of the school then typically will make high speed runs about the bow and stern wake of the vessel. They are snared as they surface off the bow.

Phocoenoides dalli is the most difficult to maintain of all the cetaceans involved in this fishery. Early attempts to capture this species were reported in Norris and Prescott (1961), and the high mortality reported by Ridgway (1966) and Wood (1973) further emphasizes the problems of their capture and acclimation.

Marineland collectors (B. Falcone personal communication 1972) reported that a major problem in securing Dall's porpoise alive is the extreme power of this animal relative to its size. Typically, an individual is snared when swimming at high speed and running at an angle to the bow of the collecting vessel. Under these conditions, the animal can suffer extensive traumatic injury during capture. This problem is further compounded by the frenzied state exhibited when it is confined or handled. On numerous occasions, individuals periodically had to be lowered into the sea in stretchers in order to calm them enough to safely continue transport to the oceanarium.

Upon arrival at the acclimation pool, these porpoises appeared to be completely disoriented. They were prone to make short bursts of speed and glance off the enclosure walls; this for periods as long as 1½ h. Even the presence of other feeding members of this species did not

appear to appreciably change the duration of disorientation. The immobilization syndrome described for *D. delphis* was also displayed by newly captive *P. dalli*. When crowded by adjacent walls, they would become immobile and sink to the bottom of the pool for short periods. Sometimes, startling this species also seemed to initiate the immobilization behavior. On one occasion, a fish thrown into the pool accidentally struck one of the animals on the head near the blowhole. This animal immediately stopped swimming; sank to the bottom of the pool; and lay there for approximately 15–20 s before rising and resuming normal captive swimming and feeding patterns. All but one of the Dall's porpoise (injured during capture) began feeding within 3 days after capture.

Mortality

Mortality during capture and transport attempts was exceptionally high. A total of eight Dall's porpoise were taken during the months of February and March 1972. Four specimens (50%) succumbed during capture and transport attempts. Of the four remaining animals (Table 5), two died within the first 60 days in captivity. One lived for approximately 3 mo. The last remaining animal survived for 15 mo. All four *P. dalli* that arrived at the acclimation pool were males ranging in size from 175 to 210 cm.

Ridgway (1966) reported a high rate of skin slough and exceptionally high daily food intake requirements. These conditions were evident in the Marineland animals as well, and support the suspected high metabolic rate for this species. Of particular interest is the rapid extreme weight loss suffered directly after capture. The two Marineland specimens that were available for observation for over 60 days never returned to their original capture weight, even with a 10- to 13-kg/day food intake.

Incidence of Naturally Occurring Parasites

On a comparative basis, all the examined *P. dalli* captured during this period were the most heavily parasitized of the cetaceans discussed in this paper. Six Dall's porpoise were available for necropsy examination. All were heavily infected with the following parasites: the nematode worm *Pharurus* sp. throughout the air sinus and inner ear complex; the lungworm *Stenurus* sp; the trematode fluke *Campula oblonga*, which caused fibrotic pancreatic abscesses; and the sinuous nematode worm *Crassicauda* sp. in the blubber and musculature of the urogenital area. The reason for this high incidence of parasitism in *P. dalli* is not known.

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Live-Capture Killer Whale (*Orcinus orca*) Fishery, British Columbia and Washington, 1962–73[1]

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BIGG, M. A., AND A. A. WOLMAN. 1975. Live-capture killer whale (*Orcinus orca*) fishery, British Columbia and Washington, 1962–73. J. Fish. Res. Board Can. 32: 1213–1221.

In British Columbia and Washington 263 killer whales (*Orcinus orca*) were caught during 1962–73 of which 50 were kept for oceanaria, 12 died during capture operations, and the remainder escaped or were released. Peak cropping years were 1967–70 when 77% of all whales removed from the water were taken. Lengths of cropped males were 2.49–6.98 m and females, 2.80–6.25 m. Of 28 females taken an estimated 43% were mature and of 30 males, 20% were adult. The equation relating body length in centimeters and weight in kilograms is $W = 0.000208\ L^{2.577}$. Revenue to netters from the sale of 48 killer whales is estimated to be about $1,000,000. Of 48 whales held in captivity 48% were still alive on April 1, 1974. Survival to the end of 2 yr in captivity is 75% in whales thought to be immature and 13% in adults. The history, capture localities and techniques, and management regulations of the killer whale fishery are also described.

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En Colombie-Britannique et dans l'Etat de Washington, on a capturé 263 orques (*Orcinus orca*) entre 1962 et 1973; de celles-ci, 50 furent maintenues en océanariums, 12 moururent au moment de la capture et le reste s'échappèrent ou furent remises en liberté. Les pics de récolte se produisirent durant les années 1967–70 alors que 77% furent capturées. La longueur des mâles est de 2.49–6.98 m, celle des femelles 2.80–6.25 m. Sur 28 femelles capturées, on estime à 48% la proportion d'individus mûrs; sur 30 mâles, 20% étaient adultes. La relation entre la longueur du corps en centimètres et le poids en kilogrammes s'exprime par l'équation $P = 0.000208\ L^{2.577}$. On estime à environ $1,000,000 le revenu aux pêcheurs qui ont capturé 48 orques. Sur 48 baleines maintenues en captivité, 48% étaient encore vivantes au 1er avril 1974. La survie après 2 ans en captivité est de 75% pour les baleines considérées comme immatures et 13% pour les adultes. Les auteurs décrivent de plus l'historique, les techniques et endroits de capture, et les règlements de gestion de la pêche des orques.

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IN recent years a unique fishery has developed in British Columbia and Washington for the live-capture of killer whales (*Orcinus orca*) to exhibit in oceanaria. The species is common here especially during the summer with a concentration of perhaps several hundred individuals off eastern Vancouver Island and in Puget Sound (Scheffer and Slipp 1948; Rice 1968; Pike and MacAskie 1969; Spong et al. 1971). Historically, no killer whales were harvested for oil and meat in British Columbia or Washington as was done in the western North Pacific and northeastern North Atlantic (Nishiwaki and Handa 1958; Jonsgaard and Lyshoel 1970). This paper gives the first published account of the fishery and includes information on development, catch statistics, economics, captive whale survival, and government management policies. The data presented were taken mainly from the records of killer whale netters and oceanaria that purchased the whales. Information was obtained from the Arctic Biological Station, Ste. Anne de Bellevue, Quebec; National Marine Fisheries Service, Seattle, Washington; Washington State Department of Game, Olympia, Washington, and published accounts of some captures (see Newman and McGeer 1966;

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Griffin and Goldsberry 1968; Anon. 1970; Taylor 1971; Bowers and Henderson 1972).

History

Interest in the killer whale as an oceanarium exhibit began in 1961 when Marineland of the Pacific, California, netted an adult female which had become disoriented in Newport Harbor, California (Caldwell and Brown 1964). This whale lived in captivity for only 1½ days. In 1962, Marineland of the Pacific captured a second adult female which died during the capture operation in Puget Sound, Washington. Interest increased during 1964 with the success of the Vancouver Public Aquarium, British Columbia, in keeping a small male alive for 3 mo (Newman and McGeer 1966). Although the whale was harpooned for a museum model by the aquarium staff, the wound was not lethal and the whale was kept alive in a temporary enclosure in Vancouver Harbour. It ate fish, displayed many of the appealing activities that characterize the species in captivity, and received much publicity. Final proof of the feasibility and entertainment value of keeping killer whales in captivity came in 1965 with the accidental netting of a large male by fishermen in Namu, British Columbia. This whale was purchased by the Seattle Marine Aquarium and towed in a floating pen about 700 km to Seattle (Griffin and Goldsberry 1968). It lived in a floating pen for about 1 yr during which time it responded well to training and attracted much interest (Griffin 1966).

In 1965, the Seattle Marine Aquarium developed a netting technique to capture live killer whales in Puget Sound. Beginning in 1968, killer whales were commercially netted in British Columbia by fishermen Messrs. Gooldrup, Reid, and Cameron, Pender Harbour, and in 1970 by Sealand of the Pacific, Victoria. In addition to the commercial operations, some whales were also taken from four accidental captures by fishermen in British Columbia and two strandings in Washington.

Capture Localities and Techniques

The main capture locations in British Columbia are Pender Harbour and Pedder Bay; in Washington they are Penn Cove and Carr Inlet in Puget Sound (Fig. 1). These are good capture localities because they are situated along the routes travelled by killer whales where water depths are less than about 35 m and tidal currents are weak.

Commercial capture localities are chosen by different methods in British Columbia and Washington because of physical geography. Puget Sound is a long narrow cul-de-sac with many inlets and shallow areas where whales are followed relatively easily and are often herded for capture. A network of observers, who live or travel in Puget Sound, locate the whales for netters. Aircraft or high speed boats track the whales until herding and netting boats can intercept the pod. Off southeastern Vancouver Island, however, the waterways are deeper and wider with few shallow regions suitable for netting. Whales have many escape routes and thus cannot be easily herded. A network of observers also alerts netters here, but captures are made essentially by waiting for whales to voluntarily enter certain shallow bays.

The netting and sorting operations are much the same in both areas. Netting vessels are 10–23 m in length and equipped with either a gillnet or table seine up to 1.6 km long and 48 m deep. When whales enter a bay, the net is set shallow enough to extend to the ocean floor; escape routes are blocked if the net is set quickly, either across the mouth of the bay or directly around the pod. Areas with strong tidal currents are avoided because tides can create escape routes in the pen or tangle the whales in nets. Once whales are trapped, additional nets are laid for reinforcement and anchors are set to hold the nets in place.

Most killer whales do not attempt to escape but rather quickly determine the pen boundaries and avoid them, apparently by echolocation. Occasionally individuals break through the nets, leaving holes large enough for others to follow. Some inadvertently tangle in loosely hanging nets and drown if not freed by divers. None escape by jumping over the net. Within a few days whales calm down and some begin to eat and play. Sorting is done in the catch pens by using smaller nets. Saleable individuals are maneuvered into a floating pen for examination, removed in a canvas sling, and shipped to oceanaria. Unsaleable whales are released.

In British Columbia, salmon fishermen accidentally captured killer whales on four occasions: at Namu, Steveston, Malcolm Island, and Port Hardy (see Tables 1 and 2). Some whales were sold from these captures. At Namu and Malcolm Island whales were trapped in shallow water by an encircling gillnet; at Steveston a 3.2-m female, which was apparently not trapped, attempted to go through a gillnet but became tangled and drowned; and at Port Hardy a single whale was trapped in a purse seine. Considering the large salmon net fishery in British Columbia and Washington, accidental captures of killer whales can be considered a rare occurrence.

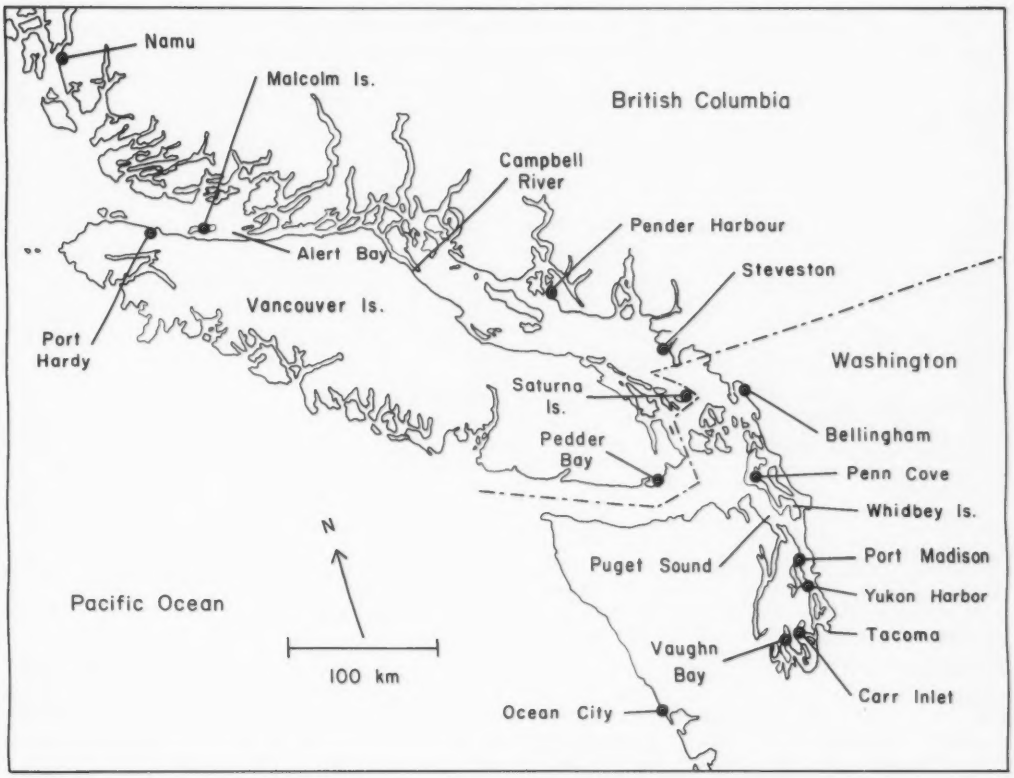

FIG. 1. Geographical locations of captures (●) and place names mentioned in the text.

TABLE 1. Killer whales (*Orcinus orca*) caught in British Columbia, 1964–73.

Date	Locality	No. captured	No. died	No. kept	No. escaped or released
July 1964	Saturna Is.	1[a]		1	
June 1965	Namu	2		1	1
July 1966	Steveston	1	1		
July 1967	Port Hardy	1		1	
July 1968	Malcolm Is.	11		1	10
Feb. 1968	Pender Harbour	1			1
Apr. 1968	Pender Harbour	7		6	1
Dec. 1969	Pender Harbour	10		6	4
Mar. 1970	Pedder Bay	5		3	2
Aug. 1973	Pedder Bay	2		1	1
Aug. 1973	Pedder Bay	2		2	
Total		43	1	22	20

[a]Harpooned.

Strandings were also rare. In British Columbia, Cameron (1941) reported a stranding of 11 individuals at Masset, Queen Charlotte Islands during January 1941; and Carl (1946) noted strandings of one individual at Cherry Point, Vancouver Island in September 1944 and of 21, including one fetus at Estevan Point, Vancouver Island in June 1945.

In Washington two strandings occurred recently in which killer whales were rescued and kept by

TABLE 2. Killer whales caught in Washington, 1962–73.

Date	Locality	No. captured	No. died	No. kept	No. escaped or released
Sept. 1962	Bellingham	2[a]	2		
Oct. 1965	Carr Inlet	15	1	1	13
Feb. 1967	Yukon Harbour	15	3	5	7
Feb. 1968	Vaughn Bay	12		2	10
Oct. 1968	Yukon Harbour	25		5	20
Apr. 1969	Carr Inlet	11		1	10
Oct. 1969	Penn Cove	7	1		6
Feb. 1970	Carr Inlet	6		1	5
Aug. 1970	Penn Cove	80	4	7	69
Aug. 1970	Port Madison	1[b]		1	
Aug. 1971	Penn Cove	15		3	12
Nov. 1971	Carr Inlet	19			19
Mar. 1972	Carr Inlet	11		1	10
Mar. 1973	Ocean City	1[b]		1	
Total		220	11	28	181

[a]One shot, one hoopnetted.
[b]Stranded.

the Seattle Marine Aquarium. In August 1970, a 2.8-m female was captured at Port Madison while disoriented in water less than 1 m deep; and in March 1973, a 4.8-m female became beached during a receding tide at Ocean City.

Number Caught

A total of 43 killer whales was caught in British Columbia and 220 in Washington (Tables 1 and 2). Although most were caught in Washington, due mainly to the larger pod sizes netted there, about the same number of whales was kept for oceanaria in both localities. In British Columbia whales were caught on 11 occasions, each of which involved less than 12 individuals. Of the total caught, 1 died during the capture operation, 22 were removed for oceanaria, and 20 escaped or were released. In Washington whales were caught on 14 occasions, 7 of which involved less than 12 individuals and 7 involved 12–80. Of the total caught, 11 died during collection, 28 were kept for oceanaria, and 181 were released or escaped. It is possible that the figure given for the total number caught in both regions included some individuals which escaped or were released more than once. Larger pods were probably captured in Washington because of the relative ease with which whales were herded in Puget Sound rather than because of regional differences in whale abundance. It is noteworthy that the capture of large herds in Puget Sound resulted in increased mortality through drowning in nets.

Figure 2 summarizes the annual number removed from British Columbia and Washington and includes whales that were kept for oceanaria plus those that died during capture operations. A total of 62 was taken, with the largest number for 1 yr being 16 during 1970. The peak harvest years were 1967–70 when 77% (48) of the whales were taken.

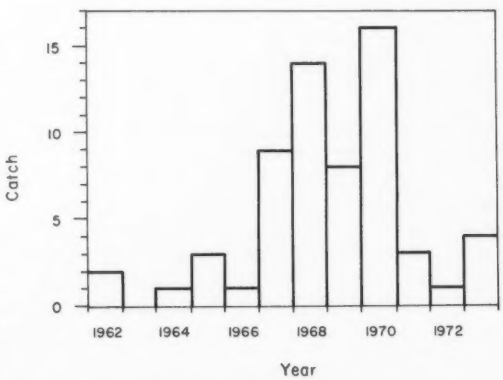

FIG. 2. Annual catch of killer whales in British Columbia and Washington, 1962–73. Includes whales that were sent to oceanaria and those that died during capture operations.

Between 1971 and 1973 only eight killer whales were removed. The following reasons were given by the commercial whale netters for the recent decline in catches. B. Gooldrup (personal communication) wrote that although killer whales still occurred in the surrounding regions, none had entered Pender Harbour since 1969. This could have been due to depletion of local pods

TABLE 3. Length frequency of 27 females and 29 males (in parentheses) at time of capture in British Columbia and Washington, 1962–73. Included are whales that died and whales that were removed for oceanaria.

Length (cm)	Year											
	1962[a]	1964	1965	1966	1967	1968	1969	1970[b]	1971	1972	1973	Total
225–249					(1)							(1)
250–274												
275–299					(1)		1	1				2(1)
300–324				1		(2)		(1)				1(3)
325–349								1(1)				1(1)
350–374					1	(1)	1	1(3)		(1)		3(5)
375–399					(1)	(2)			1			1(3)
400–424		(1)	1		(1)	1	1(1)		(1)			3(4)
425–449					(1)	(1)		1	1			2(2)
450–474					1		(1)	1(1)				2(2)
475–499											1	1
500–524						(1)	1					1(1)
525–549						1(1)					1	2(1)
550–574											(1)	(1)
575–599			1		1	2(1)		1			1	6(1)
600–624	1					1	(1)					2(1)
625–649												
650–674			(1)									(1)
675–699					(1)							(1)

[a]In addition, one adult male was killed.
[b]In addition, one adult female and two whales about 8 ft (244 cm) long of undetermined sex were drowned.

that used to enter Pender Harbour or to the whales having been more wary since capture operations began. Also, increased local boat traffic and public sentiment against killer whale netting have reduced the capturing effort. R. Wright of Sealand of the Pacific (personal communication), felt that pods were more cautious about entering Pedder Bay after capture operations began there. D. Goldsberry of the Seattle Marine Aquarium (personal communication) stated that restrictions on capture localities in Puget Sound (see Management) and an associated breakdown in the network of observers reduced capture success. From these comments it appears that in the future the annual take will not reach previous levels unless new catching localities or methods are found.

Size and Sex

Table 3 gives the length and sex of 56 killer whales that died or were removed from British Columbia and Washington. The lengths noted were within the ranges recorded for the species in other studies. In the North Pacific and North Atlantic Oceans killer whales are born at 2.1–2.7 m in length with females growing to 7.5 m and males 8.5 m (Zenkovich 1938; Nishiwaki and Handa 1958; Jonsgaard and Lyshoel 1970). Whalers report females grow to 8.2–8.5 m and males 9.4–9.7 m. In British Columbia and Washington the smallest whale examined was a male 2.49 m long, captured on February 15, 1967. Two other small whale about 8 ft (2.44 m) long were caught on August 9, 1970. Although some suckling young were taken and successfully kept alive (see Griffin and Goldsberry 1968), netters preferred to take young animals that were weaned and in the length range 3.5–4.7 m. Whales up to 6.1 m were taken for oceanaria; larger individuals were considered too bulky for oceanarium facilities or for shipment by conventional air transport. Namu, a 6.5-m male, was transported and kept in a floating pen (Griffin 1966). Thus, larger whales that were captured with the pod were seldom examined. The largest female examined was 6.25 m and the largest male was 6.98 m. If, as Jonsgaard and Lyshoel (1970) suggested for killer whales in the North Atlantic, the maturation length is 4.9 m for females and 5.8 m for males, then 43% (12) of the 28 females removed were mature, while only 20% (6) of the 30 males were mature.

Length and weight were recorded for 16 males and 16 females. Figure 3 shows the length–weight relationship. No significant differences occur in regression equations calculated for males and females. Pooled data from both sexes for the length–weight relationship are expressed in the following equation:

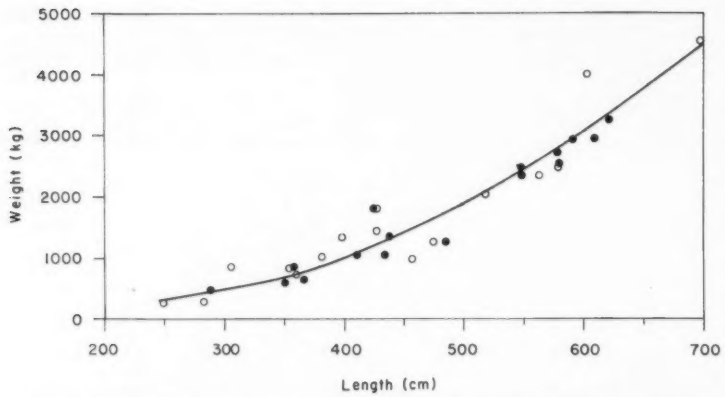

FIG. 3. Body length–weight relationship of 16 males (○) and 16 females (●) caught in British Columbia and Washington. The relationship is expressed by the equation $W = 0.000208\ L^{2.577}$

$$W = 0.000208\ L^{2.577}$$

where W is weight in Kg and L is length in centimeters. The equation was derived by the iterative method of Pienaar and Thomson (1969).

Data of Nishiwaki and Handa (1958) and Jonsgaard and Lyshoel (1970) suggest that for killer whales less than about 6.0 m, the sex ratio is close to one. Of 51 whales under this length taken in British Columbia and Washington, females comprised 49% (25) and males 51% (26).

Economic Value

Few figures are available on the prices paid by oceanaria for killer whales. The first animal was purchased in 1965 for $8000 (Griffin 1966). During 1970 the average price in Washington was reported to be about $20,000 per whale (Anon. 1970). In England a killer whale was rumoured to be for sale recently for about $72,000 (Anon. 1974). Prices rose considerably after 1970 when a rapid increase in demand for live killer whales was coupled with a reduction in captures. Although most sale prices for individual whales are a closely kept secret, discussions with whale netters indicate that the total revenue for netters in British Columbia and Washington was around $1,000,000 for 48 whales that were sold to oceanaria.

Survival in Captivity

Table 4 summarizes data on survival times of 48 killer whales held in oceanaria. The whales were exhibited in eight countries: United States (nine institutions), Canada (three), England (three), France (one), Germany (two), Netherlands (one), Australia (one), and Japan (one). Of the total held, 48% (23) were still alive on April 1, 1974. A comparison of survival rates between whales thought to be mature and immature, as based on lengths at sexual maturity for males and females given by Jonsgaard and Lyshoel (1970), indicates that mature animals at capture had a much lower survival rate than immature animals. The following annual survival rates were found for mature and immature whales, based on data from animals caught in 1964–70 and held for up to 3 yr in captivity:

	No.	1 yr	2 yr	3 yr
Immature	32	84%	75%	63%
Mature	8	38%	13%	13%

Survival rate of immature animals which was 6 times greater by the end of the second year than in adults could have resulted from either difficulties in acclimatization of adults to captivity, or initial old age. Based on data from 1965 to 1969, the survival rate changed little from 3 to 7 yr in captivity. Three individuals still alive after 7 yr 2 mo have lived the longest in captivity.

Management

The development of management regulations for killer whales in British Columbia and Washington was largely determined by local public concern over removal or harrassment of the species in marine recreational areas off south-

TABLE 4. History of survival for 38 immature[a] and 10 mature killer whales held in oceanaria up to April 1, 1974.

Year caught	Catch	Years completed in captivity						
		1	2	3	4	5	6	7
1964	Immature 1	0						
	Mature 0							
1965	Immature 1	1	1	1	1	1	0	
	Mature 1	1	0					
1967	Immature 6	5	4	4	4	3	3	3
	Mature 0							
1968	Immature 9	8	8	7	7	7		
	Mature 4	1	1	1	1	1		
1969	Immature 5	5	4	3	3			
	Mature 2	1	0					
1970	Immature 10	8	7	5				
	Mature 1	0						
1971	Immature 3	3	3					
	Mature 0							
1972	Immature 1	1	1					
	Mature 0							
1973	Immature 2							
	Mature 2							

[a]Based on Jonsgaard and Lyshoel (1970) immature = <4.9 m in length in females and <5.8 m in males.

FIG. 4. Sportfishermen photographing an adult male, female, and calf killer whale off southeastern Vancouver Island.

eastern Vancouver Island and in Puget Sound (Fig. 4). A public controversy over management policies has resulted, particularly in Washington State (see Scheffer 1967; Haley 1970; Anon. 1970; Mitchell, 1975, p. 74–75).

Prior to protective legislation, permits were required in British Columbia from the Federal Department of Fisheries to net killer whales although no catch quotas were placed on Canadian netters. Eight permits were issued to Canadians from 1966 to 1970. Two permits were issued to a California oceanarium for a catch of two whales

in 1965. Federal protection from harrassment, capture, and killing was extended to killer whales in 1970 with provisions made for permits to capture some whales for oceanaria. The Canadian Federal Department of the Environment, Fisheries and Marine Service, was given the responsibility for issuing permits and enforcing regulations. This agency allowed the following number of whales to be taken for each year since 1970: 12 in 1971, 11 in 1972–73, and 8 in 1974.

Some of the more important current regulations in British Columbia are: netters require adequate whale handling experience, facilities, and veterinary help; only whales of lengths 3.4–5.5 m can be removed; no whales can be taken from northeastern Vancouver Island between Campbell River and Alert Bay because of a high concentration of killer whales in this recreational region; and no white killer whales may be caught. The latter restriction arose from public concern over a white individual captured near Victoria in 1970 (Best and Angus 1970). White killer whales are periodically seen in British Columbia (Carl 1959).

Prior to protective legislation by the State of Washington permits were not required and limits were not set for the capture of killer whales. In 1971 the species was protected by Washington state legislation with management responsibility given to the State Game Department. Under provisions of the federal Marine Mammal Protection Act of 1972 management responsibility was transferred to the Secretary of Commerce. Governmental agencies issued permits for taking the following numbers of whales: six in 1971, four in 1972–73, and four in 1974–76. The latter number may be increased before the permit expires in 1976.

Federal regulations require netters to have adequate whale handling experience, facilities, and veterinary help, and only whales of lengths 3.4–4.9 m can be removed from the water. In 1972 under State regulation, whale netting was not permitted in Puget Sound seas to prevent harassment of whales near human recreational locations. In 1973–74, under Federal regulations, this restriction was modified to disallow netting only between Tacoma and southern Whidbey Island in Puget Sound. During 1971 and 1972 the Department of Game levied a $1000 fee for each whale removed from the water.

Beginning in 1974, Canada and the United States issued permits for capturing killer whales on the basis of a coordinated informal management arrangement between the Department of the Environment and the National Marine Fisheries Service. The gradual reduction in numbers reflects an increasingly cautious policy of the two governments with respect to cropping until research on population abundance can establish harvest limits.

Acknowledgments

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By-Catches of Harbour Porpoise (*Phocoena phocoena*) in Salmon Driftnets at West Greenland in 1972[1]

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LEAR, W. H., AND O. CHRISTENSEN. 1975. By-catches of harbour porpoise (*Phocoena phocoena*) in salmon driftnets at West Greenland in 1972. J. Fish Res. Board Can. 32: 1223–1228.

On the basis of the catch-per-unit-effort of harbour porpoises (*Phocoena phocoena*) by commercial vessels, an estimate was obtained of the number of porpoises killed by the non-Greenlandic vessels fishing for salmon at West Greenland. During 1972 the estimated kill was 1500. The distribution of porpoises based on catches by commercial and research vessels is also discussed.

LEAR, W. H., AND O. CHRISTENSEN. 1975. By-catches of harbour porpoise (*Phocoena phocoena*) in salmon driftnets at West Greenland in 1972. J. Fish. Res. Board Can. 32: 1223–1228.

En nous basant sur la prise par unité d'effort de marsouins (*Phocoena phocoena*) des navires commerciaux, nous estimons le nombre d'individus tués par les bateaux non groenlandais pêchant le saumon au Groenland occidental. On estime à 1500 le nombre d'animaux tués en 1972. Nous analysons également la répartition des marsouins fondée sur les prises des navires commerciaux et de recherche.

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DURING the course of the Joint ICES/ICNAF Salmon Tagging Experiment at West Greenland during autumn 1972, information was obtained on by-catches in salmon driftnets. The catches of seals, porpoises, and seabirds by salmon driftnets in Greenland waters were of sufficient magnitude to arouse the attention and the sentiments of the public. Fears were expressed that these incidental catches might compete with local hunting and that the survival of one species, Brunnich's guillemot (*Uria lomvia*) might be menaced (Tull et al. 1972).

This paper deals solely with the by-catches of harbour porpoises (*Phocoena phocoena*) in driftnet catches of non-Greenlandic vessels, and estimates, on the basis of the catch-per-unit-effort, the total kill of this species in the non-Greenlandic driftnet fishery. Mention is also made of the capture of one pilot whale (*Globicephala melaena*) and one other unidentified whale by observer vessels.

Gear and Methods

By-catches were recorded by the scientific staff of four research vessels and observers placed on board eight commercial vessels (in the following called "observer vessels") over the whole salmon fishing season, i.e. from the end of July to mid-October.

Each set of data on by-catches was accompanied by information on position, date, and the time of the day the nets were shot and hauled. With a view to showing in a perspicuous way the occurrence of the single species in relation to time and place, the by-catches were grouped by week, by coastal area, and by distances (subareas) from the West Greenland coast. The divisions were selected with special reference to an appropriate distribution of the salmon fishery on fishing grounds. The designations and the boundaries of areas and subareas (see Fig. 1) are the following:

Area I	70°30′N–68°40′N Disko Bank and coastal bank west of Disko
Area II	68°40′N–66°35′N Store Hellefisk Bank

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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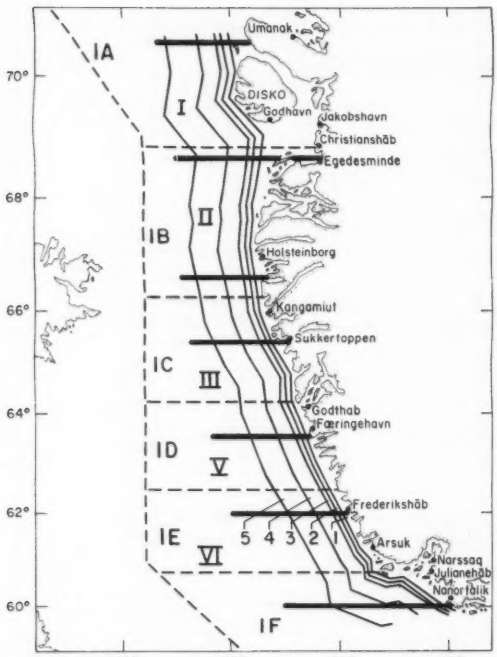

FIG. 1. West Greenland — ICNAF Divisions 1A–1F, fishing legend areas (I–VI), and subareas (1–5).

Area III	66°35′N–65°25′N Lille Hellefisk Bank
Area IV	65°25′N–63°35′N Sukkertoppen Bank and Fylla Bank
Area V	63°35′N–62°00′N Fiskenaes Bank and Dana Bank
Area VI	62°00′N–60°00′N Coastal Bank West and South of Arsuk
Subarea 1	Inside Baseline
Subarea 2	Baseline – 6-mile limit
Subarea 3	6-mile limit – 12-mile limit
Subarea 4	12-mile limit – 30-mile limit
Subarea 5	30-mile limit – 60-mile limit

A few sets were made outside the divisions above. The corresponding by-catches are referred to the Davis Strait and the Labrador Sea, north and south of latitude 60°00′N, respectively.

The majority (more than 90%) of the driftnets operated by the commercial vessels were manufactured from 0.5–0.6 mm monofilament nylon twine with a mesh size of 130–140 mm. The remainder were multifilament nylon nets. The length of the nets varied from 18 to 37 m, but by far the majority were about 33 m; they extended from the surface to a depth of about 5 m. The top of the net was kept afloat by floats or a floating rope. The net area was relatively tightly stretched since a combined sinking and hauling rope with a lead core was mounted to the footrope.

Usually 100 nets are tied up in a so-called "link" measuring a total of about 1.8 nautical miles. The links, equipped with buoys for the purpose of identification, are set in straight lines. However, depending on wind and current, the link will curve and often form a U-shaped line which, in good weather, results in increased fishing efficiency. In the case of stormy weather or strong current the loops may collapse and naturally the consequence is decreasing fishing power of the gear.

The maximum number of nets operated by the commercial vessels in 1972 varied between 850 and 450; on an average, 440 nets were used per set, amounting to a total length of 7.8 nautical miles. In most cases the nets were set about sunset. Hauling started before sunrise and usually finished before noon, depending on weather, number of nets entangled, number of seabirds as by-catches, etc. This line of procedure applied to 80% of the sets made by the observer vessels. The rest of the sets were made after midnight and at varying times of the day and were often of shorter duration and with fewer nets owing to unfavorable weather or ice conditions or proximity to the shore.

In contrast to the commercial gear, the nets used by the research vessels were 46 m long, 3–4 m deep, half with a mesh size of 130 mm and half with 150 mm, and manufactured of monofilament twine exclusively.

The main purpose of the driftnetting research, to produce a maximum number of viable salmon suitable for tagging, made special demands on the net operation. Fewer nets were used, maximum 120, averaging 45 (1.1 nautical miles) and fishing time was much shorter than in the commercial fishery. Moreover fishing had to carried out mainly in daylight.

The basis for the present estimates is the information on the total effort in 1972 of the non-Greenlandic salmon fleet, comprising 12 Danish, 4 Faroese, and 6 Norwegian vessels. The only effort data available from all vessels are number of nets used × sets made. Consequently, catch-per-unit-effort of the by-catches reported on by the observer vessels has to be expressed as number of individuals caught per nets set. Table 1 shows the total effort of the non-Greenlandic salmon fleet grouped by weeks, by area, and by subareas 1–4 and 5. Lack of exact fishing positions of some of the vessels does not allow a more detailed grouping by subarea.

The catch-per-unit-effort data obtained by the research vessels are omitted from the total by-catch estimations, as research fishing differs significantly from commercial fishing, as already mentioned. Research and observer data are kept separate in estimating number of individuals caught per mile-hour as indices of relative abundance.

The catch-per-unit-effort data of by-catches based on the records from the eight observer vessels are valid only for the estimation of total by-catches in the salmon fishery by the vessels not registered in Greenland.

The data on by-catches of porpoises in the non-Greenlandic driftnet fishing are presented in the following manner:

(1) Occurrence and relative abundance and/or

TABLE 1. Total numbers of nets used by non-Greenlandic vessels in the driftnet salmon fishery at West Greenland in 1972.

Week no.		32	33	34	35	36	37	38	39	40	41	42	43	44
Area	Sub-area	30/7–5/8	6/8–12/8	13/8–19/8	20/8–26/8	27/8–2/9	3/9–9/9	10/9–16/9	17/9–23/9	24/9–30/9	1/10–7/10	8/10–14/10	15/10–21/10	22/10–28/10
I	1–4		500			23735	33873	10870	11000	8796	3290			
	5						440		880	10000	1925			
II	1–4		20620		8566	23350	10620	9915	3325	1325	7125	2850	300	900
	5							1300	1200	2525	725			
III	1–4	20554	19224	34746	16190	7300		3200	3340	6770	2000			
	5	3480	1680						6300	2950				
IV	1–4	1400	1000	1925	8590	5445	3880	5600	4180	1200	800	2600	1900	
	5	1300	1450						300					
V	1–4	7220	17020	27850	15538		700	5308	11850	5400	5590	7000	2400	500
	5			100	300				1000		145			
VI	1–4	650	1115	220	900	7200	3840	2420	4180	689	400			
	5													
Total	1–4	29824	59479	64741	49784	67030	52513	37313	37875	24180	19205	12450	4600	1400
	5	4780	3130	100	300		440	1300	9680	15475	2795			

TABLE 2. Catch and catch-per-unit-effort of porpoises taken in commercial salmon driftnets at West Greenland in 1972.

Week no.		32	33	34	35	36	37	38	39	40	41	42	43
Sub-Area	area	30/7–5/8	6/8–12/8	13/8–19/8	20/8–26/8	27/8–2/9	3/9–9/9	10/9–16/9	17/9–23/9	24/9–30/9	1/10–7/10	8/10–14/10	15/10–21/10
Number caught per 100 mile-hours of nets (in parentheses, number reported by observer vessels)													
I	1					< 1(1)	0						
	2					0	0	0					
	3					< 1(3)	< 1(6)	0	1(10)	0			
	4		8(5)			< 1(6)	< 1(2)	0		0	0		
	5						0			0	< 1(1)		
II	1												
	2					< 1(10)	< 1(2)	0			< 1(1)		
	3		2(8)		0	< 1(14)	0	< 1(1)			< 1(1)		
	4		2(24)		2(1)			0	< 1(2)	0	< 1(1)		
	5												
III	1									4(2)			
	2	1(2)	2(4)	2(38)	< 1(7)	2(18)		0		0	0		
	3	5(30)	2(22)	2(33)	1(8)	0		0	0		0		
	4	2(15)	2(9)	1(4)	0			0		0			
	5	2(8)	2(10)						< 1(6)	< 1(3)			
IV	1												
	2	5(3)		2(4)	1(9)	1(3)		6(3)					
	3	12(5)		< 1(1)	< 1(1)								
	4	< 1(2)			< 1(1)								
	5	0	2(9)										
V	1		< 1(4)					2(2)					
	2		3(36)	1(15)	4(31)			6(15)	3(23)	3(22)	< 1(6)	2(12)	3(7)
	3	< 1(1)	0	1(14)									
	4		1(4)	0	3(3)			3(3)	0				
	5			0					1(2)				
VI	1	0	0										
	2		0		0								
	3			0									
	4												
	5												
Number caught per 100 nets													
I			1.00			0.08	0.04	0	0.17	0	0.06		
II			0.45		0.09	0.21	0.06	0.02	0.24	0	0.08	0.17	
III		0.77	0.54	0.50	0.20	0.40		0	0.13	0.15	0		
IV		0.48	0.62	0.31	0.19	0.24		1.00					
V		0.12	0.54	0.30	0.58			0.80	0.43	0.71	0.38	0.40	0.64
VI		0	0	0	0								

TABLE 3. Catch and catch-per-unit-effort of porpoises taken by research vessels at West Greenland in 1972. One mile-hour represents 1 mile of driftnet fished for 1 h.

Week	Area	Subarea	No. caught	No. caught/100 mile-hours
33	II	4	3	9
	IV	2	1	4
	V	3	2	21
34	II	3	1	1
	III	3	1	4
36	II	4	1	4
37	V	2	1	3
	VI	5	2	8

availability, shown by week, area, and subarea as number reported and estimated number caught per 100 mile-hours of nets fished. In the case of the porpoises, the catch and catch-per-unit-effort are shown in separate tables for observer vessels and for research vessels.

(2) Estimates of the total number captured by the non-Greenlandic fleet in 1972. The basic material is total effort in number of nets set (Table 1) and estimates on number of individuals captured per 100 nets set (shown at the bottom of the table of occurrence [Table 2]).

Results

The total numbers of harbour porpoises (*Phocoena phocoena*) reported as by-catches by the vessels engaged in the International Salmon Tagging Experiment at West Greenland in 1972 was 573 (561 by observers on commercial vessels [Table 2] and 12 by research vessels [Table 3]).

The occurrences were relatively evenly distributed over the whole season and on all fishing grounds (Table 2). Besides the catches along the West Greenland coast two individuals were reported from a survey fishery in Davis Strait (lat. 62°55′N, long. 59°40′W) in late September.

On the basis of the above catch and effort data, the estimated number of harbour porpoises entering the commercial salmon fishery by non-Greenlandic vessels in 1972 was 1500. One juvenile long-finned pilot whale (*Globicephala melaena*) was caught by a commercial vessel during September 18, 1972, at 63°30′N, 53°00′W (Area V, Subarea 5). One unidentified whale was caught by a commercial vessel during August 27, 1972, at 65°00′N, 53°30′W (Area IV, Subarea 5).

Discussion

The northern limit of *Phocoena phocoena* appears to lie north of Davis Strait off West Greenland (Mercer 1973). Jensen (1928) also documented its occurrence in southwestern and West Greenland to Upernavik and in East Greenland (Angmagssalik) in summers with little ice; he gave an annual kill of 300–600.

On the basis of catch-per-unit-effort in salmon driftnets it is shown that the porpoise occurs along the West Greenland coast in the period July 30 until October 21. Greatest abundance and/or availability is during the first half of August from Frederikshaab to Disko. The relative abundance and/or availability decreases generally from August to October but they are still present as far north as Area I (Disko–Umanak) in early October.

The estimated kill of porpoises, based on catch-per-unit-effort data, by the non-Greenlandic driftnet fishery during 1972 was 1500.

These data cannot be used directly for estimating the by-catches entering the local Greenlandic salmon fishery since the two fisheries are dissimilar. The home salmon fishery is carried out partly with set gillnets on the coast and in the fjords and partly with driftnets inshore as well as offshore, but generally closer to the coast than the fishery by the non-Greenlandic vessels.

Research fishing with salmon set gillnets indicates that the by-catches in this type of gear differ significantly both qualitatively and quantitatively from the by-catches entering the driftnets. The individuals retained by the set gillnets belong mainly to fish species; apart from salmon, most frequently cod and lumpsucker. Porpoise and seal are considered to be much less available to set gillnets (S. Aa. Horsted personal communication).

No information exists on the composition and amount of by-catches in the driftnets operated by vessels registered in Greenland. The local vessels, however, at least until 1972, were mainly equipped with the more visible multifilament nets and these vessels, being smaller in size, generally driftnetted closer to shore and consequently operated to a greater extent in daylight. [A direct catch of 1000 porpoise per annum is also made — see paper by Kapel, this volume.]

Even if the by-catch-per-unit-effort values based on the information obtained from the observer vessels are supposed to represent the capture rate of the Greenlandic driftnetters, the total by-catches taken by this part of the salmon fleet will still be a guess, as relevant effort data are not available. If the total yield of salmon in the local driftnet fishery can also be used as an index of relative effort for comparison with total yield of the non-Greenlandic fishery, a basis for an estimate of the by-catches in the home fishery is established. In 1972 the total catch of salmon by Greenlanders amounted to 1320 metric tons. The driftnet fishery was responsible for more than 50%, i.e. a total catch of the same order of magnitude as the total catch by the non-Greenlandic salmon fishery, at about 700 metric tons. In the 1970 and 1971 seasons the quantity of salmon taken by the Greenlandic driftnetters was probably about the same or less than that taken by the non-Greenlandic driftnetters.

Just as the catch-effort values of the by-catches reported by the observer vessels are considered to represent the by-catch rates in the non-Greenlandic driftnet fishery, in the same way these catch-effort values are valid only for the evaluation of total by-catches in the season 1972. The occurrence and abundance of the species entering the salmon driftnets may change so much from season to season that the present data cannot be used without reservation for calculations of seasonal total by-catches in general.

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Incidental Catch of Cetaceans with Salmon Gillnet[1]

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OHSUMI, S. 1975. Incidental catch of cetaceans with salmon gillnet. J. Fish. Res. Board Can. 32: 1229–1235.

Using datá on number of cetaceans caught per 1000 "tans" (= approximately 50 m) of salmon drift gillnet, incidental catch rates by salmon research vessels of the Japanese Fisheries Agency averaged 0.476. The maximum was 1.42. The average ranged between 0.37 and 0.65 from 1962 to 1971, indicating negligible effect on porpoise populations. These figures are much lower than the average incidental catch rate (6.66) in the United States salmon drift net research. The main catch is *Phocoenoides dalli*.

OHSUMI, S. 1975. Incidental catch of cetaceans with salmon gillnets. J. Fish. Res. Board Can. 32: 1229–1235.

En se basant sur le nombre de cétacés capturés par 1000 « tans » (approximativement 50 m) de filet maillant dérivant à saumon, on estime à 0.476 en moyenne le taux de capture fortuite de cétacés par les navires de recherche sur le saumon de la Japanese Fisheries Agency. Le taux maximum est de 1.42. La moyenne, entre 1962 et 1971, varia de 0.37 à 0.65, ce qui indique un effet négligeable sur les populations de dauphins. Ces chiffres sont de beaucoup inférieurs au taux de capture fortuite moyenne (6.66) dans la pêche expérimentale du saumon au filets maillants aux Etats-Unis. La principale espèce capturée est *Phocoenoides dalli*.

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A large number of cetaceans are incidentally killed by different types of fisheries in the world. The incidental kill of some kinds of dolphins by the tuna purse seine net fishery in the eastern tropical Pacific (Perrin 1968) has aroused public concern in recent years. Some kinds of dolphins, mainly the La Plata dolphin (*Pontoporia blainvillei*), are incidentally caught with shark gillnets on the Rocha coast of Uruguay (Pilleri 1971). Dolphins are caught incidentally with purse seine nets, fixed nets, trawls, etc. in the coastal fisheries of Japan (Ohsumi 1972).

Many kinds of marine animals, including cetaceans, are entangled with drift gillnets in the salmon gillnet fishery of the northwest North Pacific. Mizue and Yoshida (1965) reported that over 10 thousand Dall's porpoises (*Phocoenoides dalli dalli*) were estimated to be incidentally killed by the pelagic salmon fishery annually. Mizue et al. (1966) and Koga (1969) described the ecology of some Dall's porpoises caught incidentally with salmon gillnets. Fukuhara (1974) recently reported on the estimated mortality of porpoises in salmon gillnet fisheries.

Based on a log book of an expedition, and the total number of salmon fishing expeditions in 1964, Mizue and Yoshida (1965) estimated that more than 10 thousand Dall's porpoises were annually killed incidentally by the salmon gillnet fisheries. Mizue et al. (1966) further noted that over 20 thousand porpoises were killed by pelagic salmon fisheries, but they did not show the basis of this estimate. Fukuhara (1974) estimated, on the basis of the catch rate of porpoises by U.S. research vessels and the total length of commercial nets, that an average of 11,800 Dall's porpoises are killed annually in the gillnets of the pelagic salmon fishery.

Although systematic research has not yet been done on the cetaceans that are incidentally killed by salmon drift gillnets, I examine here the cetacean species, distribution, and seasonal and yearly change in catch rates of cetaceans, so as to estimate the effects of salmon fisheries on cetacean populations.

Materials

The Fisheries Agency of the Japanese government has been conducting basic renewable resources research on salmon, independently from commercial salmon fisheries, using several research vessels in the

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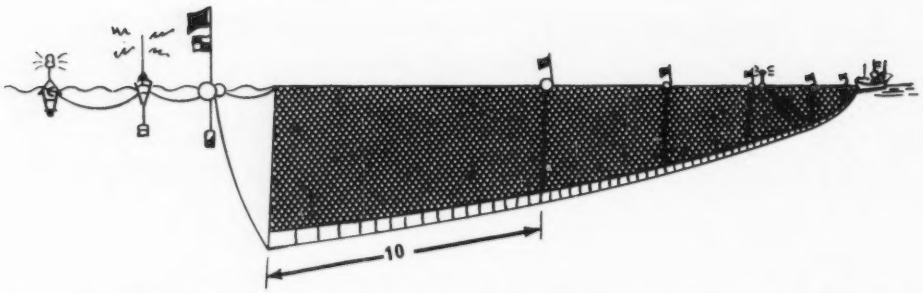


FIG. 1. Schematic figure of throwing gillnet by a salmon fishing boat (from Tsuya 1973). The length (10) given is in "tan," where one "tan" is approximately 50 m.

northern part of the North Pacific. The researchers on board work mainly on the population of salmon caught with drift gillnets or longlines. They also record the species and the number of animals that were incidentally caught. As there are no records for the catch of Cetacea with longlines, and it is not the aim of the present paper to study that problem, I used only the data from gillnet catches.

Salmon drift gillnets are about 6 m in depth. Their unit of length is a "tan" (= about 50 m). Gillnets with mesh sizes of 48–157 mm are used simultaneously on research vessels, whereas mesh sizes of 121–131 mm are used in commercial fisheries. The length of the nets used on the research vessels varies from 60 to 150 tans, depending on conditions, and the purpose of the research being done. Commercial gillnets are 300 tans long.

Salmon gillnets are thrown into the water from fishing boats in the evening and are picked up the next morning (Fig. 1). When a cetacean touches a net, it becomes entangled and drowns.

I used as my basic data the records of date, position, length of gillnet, and species and number of cetaceans caught. Since marine mammals that are incidentally caught are not the main objects of salmon research, the researchers are usually not knowledgable about cetacean taxonomy. As a result, cetacean species are usually only roughly identified. In many cases cetaceans of 3 m or longer are recorded as whales, and smaller cetaceans as dolphins. Sex, body length, and other measurements are not included in the research form.

The data used in this paper were collected from 1962 to 1971. The research seasons are distributed from the beginning of February to the earlier half of October (Table 1). Research areas are in the Bering Sea, the northern part of the North Pacific, the Sea of Okhotsk, and the Sea of Japan, covering the waters of 37°–67°N and 128°E–150°W.

Cetacean Species Caught with Salmon Gillnet

Of the 525 cetaceans recorded, 519 (98.9%) were classified as porpoises. This includes Dall's porpoises, True's porpoises, and harbour porpoises. Only six (1.1%) were so-called whales. Baird's whales and pilot whales were among the "whales" incidentally caught.

The number of cetaceans identified by the researchers to species are as follows:

Dall's porpoise, *Phocoenoides dalli dalli*	37
True's porpoise, *P. d. truei*	11
Harbour porpoise, *Phocoena phocoena*	1
Pilot whale, *Globicephala* sp.	1
Baird's beaked whale, *Berardius bairdii*	2

Forty-nine of the 52 cetaceans, or 94%, were porpoises. This ratio is almost the same as that obtained from the crude data mentioned earlier.

Mizue and Yoshida (1965) examined 54 cetaceans and noted that they were all Dall's porpoises. Mizue et al. (1966) identified 148 Dall's porpoises, one harbour porpoise, and one Baird's beaked whale. All 35 cetaceans that Koga (1969) identified were Dall's porpoises. According to Fukuhara (1974), 91 porpoises caught with salmon gillnets by U.S. research vessels were all Dall's porpoises.

These results indicate that cetaceans which are incidentally caught with salmon drift gillnets are mostly *Phocoenoides dalli*.

Distribution of Cetaceans Caught with Salmon Gillnets

Cetaceans were caught in most of the research areas, but the catches are not uniformly distributed (Fig. 2). Relatively many catches were recorded on the west coast of Kamchatka Peninsula and in the waters of 42°–50°N of the northern part of the North Pacific.

Figure 3 shows the positions of cetaceans identified to species by researchers. The data are limited to the area on the North Pacific side of the Kuril Island chain. The most characteristic feature in this figure is that True's porpoises are distributed only in the waters off Japan and the Kuril Islands. The northern limit of True's por-

TABLE 1. Seasonal change in lengths of gillnets and number of cetaceans caught with them, 1962–72. Abbreviations are: E: Earlier half, L: Later half, P: Porpoise, D: Dall's porpoise, T: True's porpoise, H: Harbour porpoise, W: Whale, B: Baird's beaked whale, G: Pilot whale.

Half month		Total tans	Cetacean species								Catch rate
			P	D	T	H	W	B	G	To.	
Feb.	E	159	—	—	—	—	—	—	—	—	0.00
	L	300	1	—	—	—	—	—	—	1	3.33
Mar.	E	14,758	—	—	—	—	—	—	—	—	0.00
	L	9,797	1	—	—	—	—	—	—	1	0.10
Apr.	E	12,573	2	—	—	—	—	—	—	2	0.16
	L	135,487	40	6	—	—	—	1	—	47	0.35
May	E	135,762	56	5	—	—	—	—	—	61	0.45
	L	137,123	54+	6	1	—	—	—	—	61+	0.44+
June	E	147,175	48	1	7	1	1	1	—	59	0.40
	L	159,534	58	1	3	—	—	—	—	62	0.39
July	E	144,874	53	1	—	—	1	—	—	55	0.38
	L	156,901	122	17	—	—	1	—	1	141	0.90
Aug.	E	29,381	26+	—	—	—	—	—	—	26+	0.89+
	L	16,744	5	—	—	—	—	—	—	5	0.30
Sept.	E	3,387	3	—	—	—	—	—	—	3	0.89
	L	1,187	1	—	—	—	—	—	—	1	0.84
Oct.	E	86	—	—	—	—	—	—	—	—	0.00
Total		1,102,228	470+	37	11	1	3	2	1	525+	0.48

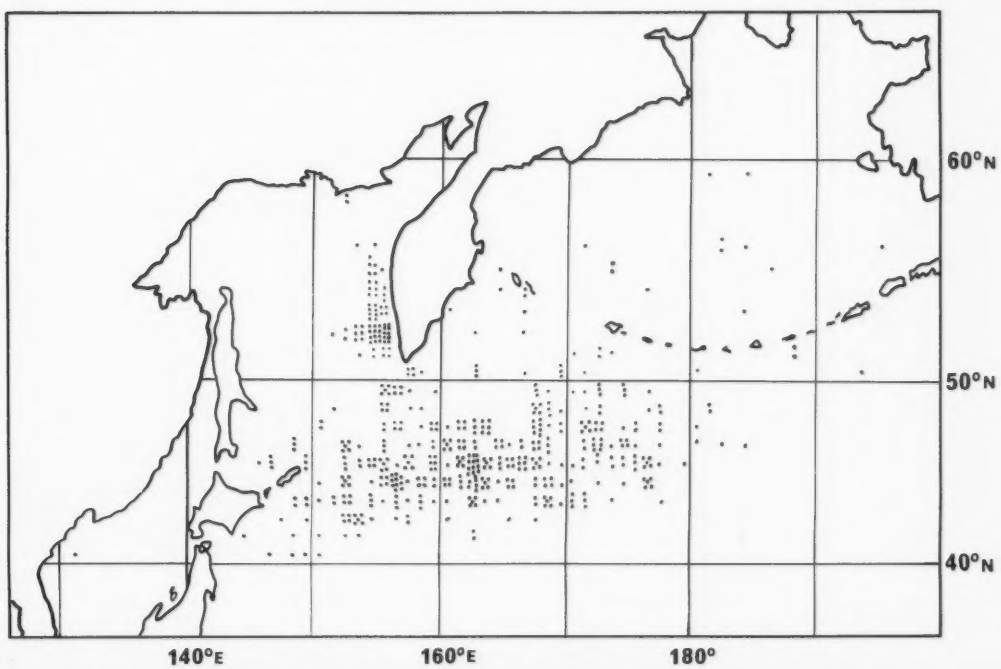


FIG. 2. Catch positions of cetaceans with drift gillnets by salmon research vessels, 1962–71.

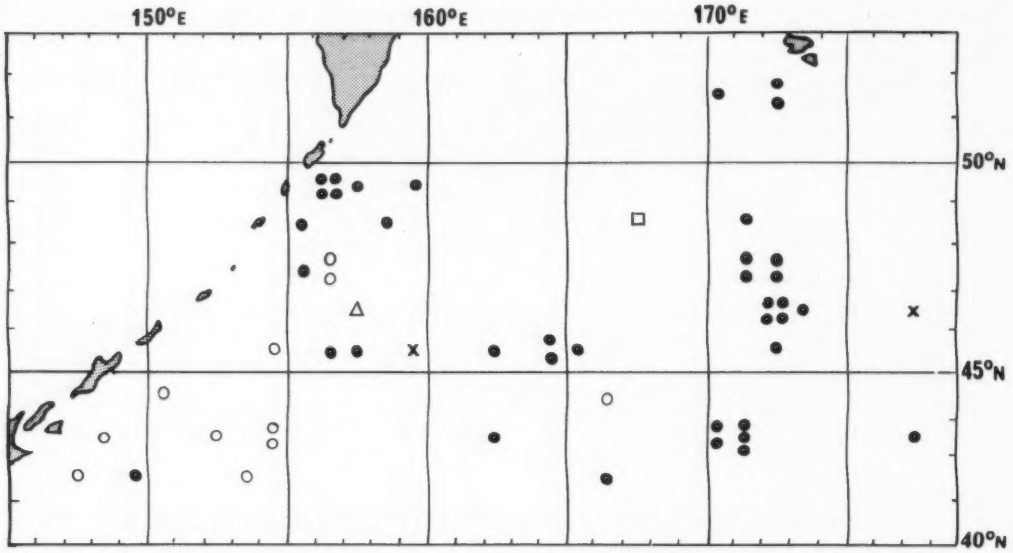


FIG. 3. Catch positions of cetaceans by species. ○: True's porpoise, ●: Dall's porpoise, △: harbour porpoise, □: pilot whale, ×: Baird's beaked whale.

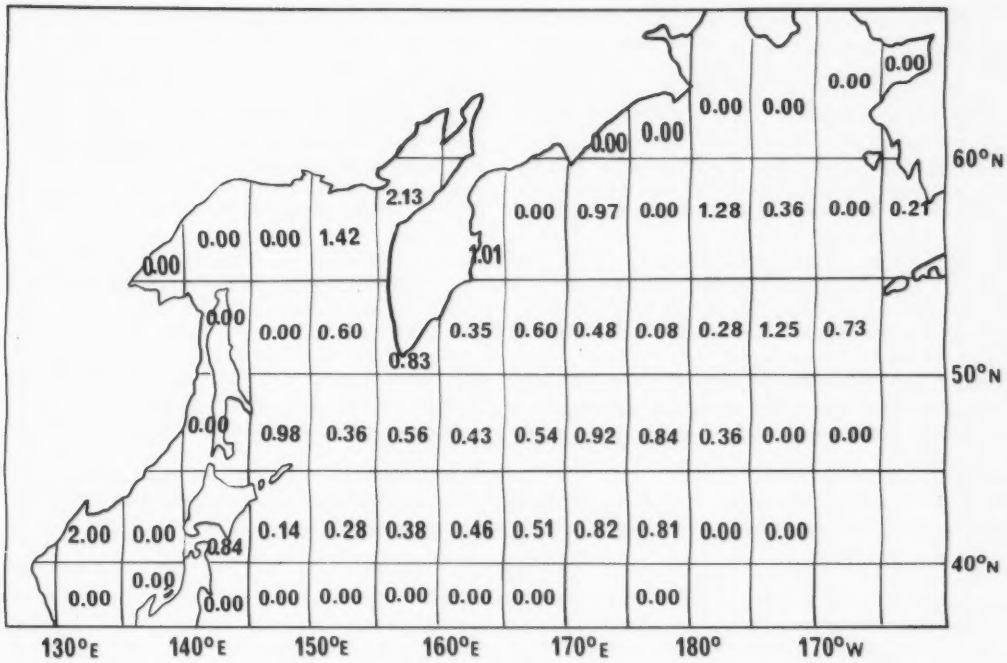
poises was 48°N, and the eastern limit was 167°E. The ranges of Dall's and True's porpoises are not clearly separated. Kuroda (1956) noted that he observed a mixed school of both porpoises in the waters off Erimo Cape, Hokkaido. As Kuroda (1954) hypothesized, True's porpoise might be only a local stock of *Phocoenoides dalli*.

As shown in Fig. 4, catch rates of cetaceans in each 5° by 5° square are not uniform. The catch rate is taken as the number of cetaceans per one thousand tans of net, and it is a kind of Catch Per Unit Effort (CPUE). Cetaceans were not caught in the waters north of 60°N in the Bering Sea and west of 151°E in the Okhotsk Sea, excluding coastal waters along Hokkaido and Kuril Island. Catch rates were relatively low in the Sea of Japan. Higher catch rates were observed in the waters off the west coast of the Kamchatka Peninsula, the center of the Bering Sea, the eastern side of Aleutian Island chain, and 170°E–180° and 40°–50°N on the North Pacific side. If the catch rate represents the real distribution density of the porpoises, it then appears that they are distributed widely in the northern part of the North Pacific, but not distributed uniformly.

In the squares where over 500 tans of net were used, the average catch rate is 0.476. The highest rate observed was 1.42. Fukuhara (1974) shows a very high catch rate (6.66) as the average in the United States fisheries research. The difference between these two results may be caused by differences in research areas, seasons, kinds of nets used, etc.

Seasonal Change in Catch Rate

Table 1 shows the length of gillnets and the catch of cetaceans in whole areas in half-month periods from 1962 to 1971. Catch rates change seasonally. They tend to increase from early spring to early autumn. Seasonal change in catch rates is further examined, separating the zones of 40°–50°N (N-zone) and 50°–60°N (P-zone) in the main research areas east of 160°E. Porpoises begin to be caught in N-zone in the later half of February, and the catch rate increases gradually until August–September. In P-zone, on the other hand, a pattern of seasonal change in catch rate shifts about 1 mo later (Fig. 5). The pattern is similar to that in the N-zone. This shows that the porpoises, mainly Dall's porpoises, migrate seasonally and move northward from early spring until early autumn. This would be why February is the best hunting season for *Phocoenoides* in the Sanriku waters (Kasuya 1971).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number and rough species name was recorded of animals incidentally caught in salmon gillnets. For the development of studies on incidental catches of cetaceans, we should offer the researchers a manual of identification of Cetacea to record species; request that they record sex, body length, fetuses, and stomach contents; and collect reproductive organs and structures from which age characters of incidentally killed cetaceans can be determined.

Five species of cetaceans were recorded in this paper. Other cetacean species must live in the waters of the northern part of the North Pacific. Several causes for their not appearing in the records may be considered: differences of population size, differences in ability to recognize and avoid the net, differences of habitat and distribution, etc. When larger cetaceans become entangled and killed in a net, they may sink with the net and therefore not be recorded.

It is surprising that some odontocetes become entangled in nets regardless of their echo-location systems. According to Pilleri (1971), it is clear that neither the width of mesh nor the thickness of cords are factors. The reasons for this inability to detect net barriers still remain to be investigated. Whether or not the ability to detect nets varies with different species also remains unsolved. If some cetaceans can recognize and detect nets, they will not be entangled in them. Such behavior may be different with differing conditions of school composition, even within the same species. If catch efficiency differs with cetacean species, it is dangerous to infer the density of cetacean populations directly from catch rates. It is also questionable whether the catch rates represent the real density of populations as distributed in the sea. For the solution of these problems, cetacean sighting investigations should be carried out independently, and experimental observations in aquaria of entangling with nets should be made on different species and differing school compositions in the same species.

An estimation of the total amount of incidental catch of cetaceans in commercial salmon fisheries should be possible from the catch rate data of cetaceans with gillnets and the total lengths of nets used. This, however, is rather difficult. There are several factors that should be considered. Commercial salmon boats use longer nets than the research vessels. Catch efficiency may differ with the length of net used. Research vessels use several kinds of nets for research purposes. These parameters may affect the catch efficiency. Catch rate changes with fishing grounds and seasons. Research vessels work over wider grounds and for longer seasons than do commercial fisheries.

With the direct collection of incidental catch data from commercial fishing boats, it is more accurate to estimate the total amount of incidental catch than the catch rate. In practice, it is rather difficult to request fishermen to identify cetacean species, to measure and sample animals, and record data. It would be useful to send a researcher on board commercial fishing boats to collect reliable data on the incidental catch of cetaceans.

Most cetaceans are lost in the sea when they are caught by salmon fisheries. Some technique should be developed to utilize them or to protect them from becoming entangled in the gillnets. After the net has been set in the water, gillnet fisheries passively wait for fish to become entangled in the nets. It is therefore difficult to actively avoid entangling of cetaceans without lowering the catch efficiency for salmon. Salmon fishermen do not like the entangling of cetaceans in their gillnets because entangled cetaceans damage their expensive nets, lower the catch efficiency of salmon, and make retrieval of their nets difficult. Dolphins are useful in locating schools of tuna for the purse seine net fishery in the tropical Pacific Ocean. However, in salmon drift gillnet fisheries, dolphins are not only independent of salmon schools, but harmful to the fishery.

Although many porpoises are incidentally caught by the salmon gillnet fisheries annually, there is no evidence to show a decline in their population density. This means that the population size of cetaceans, mainly of Dall's porpoises, is remarkably large, and that the effect of incidental catch of cetaceans is negligible.

FUKUHARA, F. M. 1974. Estimated mortality of seabirds, fur seal, and porpoise in Japanese salmon drift net fisheries and sea lions in the eastern Bering Sea trawl fishery. 13 p. (On file in Far Seas Fisheries Research Lab., manuscript of paper presented at U.S.–Japan Fisheries meeting, Washington 1973.)

KASUYA, T. 1971. Consideration of distribution and migration of toothed whales off the Pacific coast of Japan based upon aerial sighting record. Sci. Rep. Whales Res. Inst. 23: 37–60 + 6 pl.

KOGA, S. 1969. On the Dall's Porpoise, *Phocoenoides dalli* (True), caught by the Japanese salmon fishing gill-net in the northern waters of the Asian side. Jour. Shimonoseki Univ. Fish. 18: 53–63. (In Japanese)

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1956. Records of pelagic mammals observed in the North West Pacific. J. Mamm. Soc. Jap. 1: 36–39. (In Japanese)

MIZUE, K., AND K. YOSHIDA. 1965. On the porpoises

caught by the salmon fishing gill-net in Bering Sea and the North Pacific Ocean. Bull. Fac. Fish. Nagasaki Univ. 19: 1–36. (In Japanese)

MIZUE, K., K. YOSHIDA, AND A. TAKEMURA. 1966. On the ecology of Dall's porpoise in Bering Sea and the North Pacific Ocean. Bull. Fac. Fish. Nagasaki Univ. 21: 1–21. (In Japanese)

OHSUMI, S. 1972. Catch of marine mammals, mainly of small cetaceans, by local fisheries along the coast of Japan. Bull. Far Seas Fish. Res. Lab. 7: 137–166.

PERRIN, W. F. 1968. The porpoise and the tuna. Sea Frontiers 14: 166–174.

PILLERI, G. 1971. On the La Plata dolphin, *Pontoporia blainvillei* off the Uruguayan coasts. Invest. Cetacea 3: 59–67 + 8 pl.

TSUYA, T. 1973. Collection of illustrations on Japanese fishing vessels-4. Pelagic salmon gill-net fishing boats. Ushio 110: 20–23.

Marking of Small Cetaceans Using "Discovery" Type Whale Marks[1]

S. G. BROWN

Whale Research Unit, I.O.S., U.K.

BROWN, S. G. 1975. Marking of small cetaceans using "Discovery" type whale marks. J. Fish. Res. Board Can. 32: 1237–1240.

All smaller cetaceans known to have been successfully marked with "Discovery" type marks are summarized. These include 67 minke whales (*Balaenoptera acutorostrata*), 33 killer whales (*Orcinus orca*), 30 pilot whales (*Globicephala* sp.), 7 bottlenose whales (*Hyperoodon* sp.), 5 other "beaked whales," and 1 dusky dolphin (*Lagenorhynchus obscurus*). Recoveries include 3 minke, 1 bottlenose, and 1 killer. Minke whale marks were recovered up to 4 yr 2 mo after marking.

BROWN, S. G. 1975. Marking of small cetaceans using "Discovery" type whale marks. J. Fish. Res. Board Can. 32: 1237–1240.

L'auteur donne un résumé de tous les petits cétacés connus comme ayant été marqués avec succès à l'aide de marques du type « Discovery ». Il s'agit de 67 petits rorquals (*Balaenoptera acutorostrata*), 33 orques (*Orcinus orca*), 30 globicéphales noirs (*Globicephala* sp.), 7 hypéroodon (*Hyperoodon* sp.), 5 autres bérardidés et 1 dauphin (*Lagenorhynchus obscurus*). Les recaptures comprennent 3 petits rorquals, 1 hypéroodon et 1 orque. Les marques de petits rorquals furent recapturées jusqu'à 4 ans 2 mois après le marquage.

Accepted March 14, 1975 Accepté le 14 mars 1975

A small number of animals of some species of the smaller Cetacea have been marked with "Discovery" type whale marks in the course of marking operations mainly directed towards the larger whales. These operations were carried out by the Discovery Committee in the prewar years, since 1945 by various authorities in different countries, and in schemes for international cooperation in whale marking.

Number of whales marked

Table 1 summarizes the results to January 1974. It is compiled from:

1. Records held at the Whale Research Unit relating to whale marking in the Southern Hemisphere from Australia, New Zealand, and the South Pacific Islands; under the International Marking Scheme, and the Discovery Committee.
2. Records of Norwegian and French whale marking in the North Atlantic held at the Unit.
3. Published and unpublished records relating to marking by Canadian, Japanese, and USSR authorities in the North Atlantic and North Pacific, and in the Southern Hemisphere.

Tables 2–5 give more details of the marking in the different oceans, with information on the sources used. The tables are believed to be complete and to include all the small cetaceans that have been successfully marked to date with "Discovery" type marks.

A total of 67 minke, 33 killer, 30 pilot, 7 bottlenose and 5 "beaked" whales, and 1 dusky dolphin have been marked. In considering these numbers it must be remembered that most of the animals have been marked incidentally in the course of operations directed towards the larger whales and that, apart from some of the marking in the North Atlantic, there has not so far been a deliberate attempt to mark any numbers of the smaller species. However, some Japanese and Norwegian marking is now being directed towards minke whales in the Antarctic and North Atlantic, respectively.

Number of marks recovered

According to the available records, marks have been recovered to date from three minke whales, one bottlenose whale, and one killer whale.

The three minke whales were all marked in the North Atlantic and the marks were recovered after intervals of 19 days, 9 mo, and 4 yr 2 mo. Two were .410 marks and one was a 12-bore mark.

The mark from the bottlenose whale was recovered 1 h after the whale had been marked in

[1]Prepared for the meeting of the "Subcommittee on Small Cetaceans, Scientific Committee, International Whaling Commission," held at Montreal, Quebec, Canada, April 1–11, 1974.

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TABLE 1. Marking of small cetaceans with "Discovery" type marks 1932–74.

	Minke whale	Killer whale	Pilot whale	Bottlenose whale	"Beaked" whale	Dusky dolphin
North Atlantic	30	6	9	2	—	—
South Atlantic	—	—	—	—	—	1
Indian Ocean	3	—	1	—	—	—
North Pacific	—	7	1	—	1	—
South Pacific	—	1	3	—	—	—
Antarctic	34	19	16	5	4	—
Total	67	33	30	7	5	1

TABLE 2. Marking of small cetaceans – Antarctic, 1932/33 to 1972/73 inclusive.[a]

Species	Period	Antarctic areas I	II	III	IV	V	VI	Total all areas
Minke whale	DC 1932/33–1938/39	—	2	1	—	—	—	3
	IMS 1945/46–1972/73	—	—	—	6	—	2	8
	USSR 1952/53–1972/73							23
	Total	—	2	1	6	—	2	34
Killer whale	IMS 1945/46–1972/73	—	1	—	—	—	—	1
	USSR 1952/53–1972/73		1					18
	Total	—	2	—	—	—	—	19
Pilot whale	IMS 1945/46–1972/73	—	—	—	—	—	4	4
	USSR 1952/53–1972/73							12
	Total	—	—	—	—	—	4	16
Bottlenose whale	USSR 1952/53–1972/73							5
"Beaked" whales	IMS 1945/46–1972/73	—	—	—	2	—	2	4

[a]Sources: 1. DC 1932/33–1938/39 = Discovery Committee marking. 2. IMS 1945/46–1972/73 = International Marking Scheme and earlier cooperative marking. 3. USSR 1952/53–1972/73 = USSR marking – figures from Ivashin 1973; and unpublished records.

the North Atlantic. The mark from the killer whale was recovered on the same day as the animal was marked in the Antarctic.

The small number of returns results from three main factors:

a) the small number of animals which have been marked

b) the relatively small catches of these species in most of the regions where they have been marked

c) the general haphazard nature of this marking to date.

Another possible factor is that a number of the animals have been marked with 12-bore marks rather than .410 marks. It is likely that some of the smaller individuals hit with 12-bore marks sustained serious injury and later died. There is evidence that sperm whales of about 21 ft (6.4 m) and 33 ft (10.0 m) in length have been killed by these marks.

TABLE 3. Marking of small cetaceans – Southern Hemisphere north of 40° S lat., 1949–74 inclusive.[a]

Species	Period	South Atlantic Ocean	Indian Ocean	South Pacific Ocean	Total all oceans
Minke whale	1949–74	—	3	—	3
	USSR 1952/53 –1972/73				8
	Total	—	3	—	11
Killer whale	1949–74	—	—	1	1
Pilot whale	1949–74	—	1	3	4
	USSR 1952/53 –1972/73				5
	Total	—	1	3	9
Dusky dolphin	1949–74	1	—	—	1

[a]Sources: 1. 1949–74 = Australian, New Zealand, and South Pacific, and South African marking, and International Marking Scheme (includes unpublished records at Whale Research Unit I.O.S.). 2. USSR 1952/53–1972/73 = USSR marking – figures from Ivashin (1973) and unpublished records.

TABLE 4. Marking of small cetaceans – North Atlantic, 1954–72 inclusive.[a]

Country	Period	Minke whale	Killer whale	Pilot whale	Bottlenose whale
Canada	1965–72	12	6	7	2
France	1966	—	—	2	—
Norway	1954–68	18	—	—	—
Total		30	6	9	2

[a]Sources: Canada — Mitchell. Progress Report on Whale Research, Canada May 1972 to May 1973 — to Scientific Committee IWC 1973. France — unpublished records from Dr Budker. Norway — unpublished records from Dr Jonsgaard.

TABLE 5. Marking of small cetaceans — North Pacific, 1949–73 inclusive.[a]

Country	Period	Killer whale	Pilot whale	"Beaked" whale
Japan	1949–73	—	1	1
USSR	1954–71	7	—	—
Total		7	1	1

[a]Sources: 1. Summarized Result of the Whale Marking in the North Pacific. 1967. 17th Report of the International Commission on Whaling p. 116–119. 2. Whale marking — Progress Reports in 18th/24th Reports of the International Commission on Whaling, 1968–74.

Discussion

The evidence so far available on the use of "Discovery" type marks on small cetaceans suggests that only the .410 marks should be used for these species. This mark was initially developed by D. E. Sergeant and the first marks were supplied by Holland and Holland Ltd. in 1955. It has been used in marking in the North Atlantic and Southern hemispheres. E. Mitchell has now developed a streamer version of this mark. The Japanese are developing a small size mark made of synthetic resin for use with a .410 gun.

Apart from the remote chance of their recovery from stranded animals, "Discovery" type marks can be recovered only from a whale fishery. Since catches of the smaller species tend to be localized, marking should, in the first instance, be directed towards obtaining recoveries from particular fisheries. This calls for specific marking programs for these species, rather than for incidental marking as has been done mostly in the past.

There appear to be good grounds for intensifying the marking of minke whales in the North Atlantic to obtain recoveries from the Norwegian fishery, on the antarctic grounds for recoveries

from the pelagic whaling catches, and in parts of the Indian Ocean and western North Pacific for recoveries from South Africa and Japan, respectively.

Experiments on the likelihood of recoveries being made from *Berardius* and *Ziphius* in the Japanese fishery, from killer whales and bottlenose whales in the Norwegian fishery, and from pilot whales in the Norwegian and Faroese fisheries, would be worthwhile. If successful, limited programs of marking of these species could be undertaken in those regions. It may be, however, that the methods of marking now being developed for dolphins (see Evans et al. 1972) will prove to be more suitable for some of these species than the "Discovery" type mark. As with the 12-bore mark, there will be a lower size limit below which the use of the .410 mark will cause serious injury and death to an animal. This limit will vary with the species and with the circumstances of marking. It has not yet been clearly defined for any species, but a sperm whale calf of 11 ft 8 inches (3.4 m) was seriously wounded by a .410 mark and it seems likely that the mark is not suitable for animals less than 15 ft (4.6 m) in length.

If the marking of the smaller species of cetaceans is to be intensified in future, whatever types of marks or tags are used, there will clearly be a need for a central agency (or agencies) to hold duplicate records of this marking and to act as a clearing house for recovery data as necessary.

EVANS, W. E., J. D. HALL, A. B. IRVINE, AND J. S. LEATHERWOOD. 1972. Methods for tagging small cetaceans. Fish. Bull. 70: 61–65.

IVASHIN, M. V. 1973. Marking of Whales in the Southern Hemisphere (Soviet materials). 23rd Report of the International Commission on Whaling. p. 174–191.

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Journal of the Fisheries Research Board of Canada

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Notes: Differ from papers on the basis of scope or completeness, rather than quality of research. They may be on problems with narrow, readily defined limits; on work that is largely confirmatory; on methodology or research techniques; on advances in knowledge arising as by-products of broader studies; on progress in projects that were discontinued; or on preliminary findings that warrant publication before problems are resolved. They may be organized with as much flexibility as articles except that they have no centered headings and should occupy no more than four printed pages.

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The *Style Manual for Biological Journals* (3rd ed. American Institute of Biological Sciences, 3900 Wisconsin Ave. NW., Washington, D.C.) is used as the authority in matters of form. The standards for spelling are: *Webster's Third New International Dictionary* and *le Grand Larousse Encyclopédique*. Titles of periodicals are abbreviated as in the *Biological Abstracts* list. References to literature are made by the name-and-year system. The *Journal* follows the names and spelling recommended in *A List of Common and Scientific Names of Fishes from the United States and Canada* (Third Edition, 1970) Special Publication No. 6 of the American Fisheries Society.

Series titles should be avoided. An *abstract* is required for all manuscripts, and should state concisely, in less than 250 words, what was done, the essentials of the new knowledge, and the main conclusions. Abstracts are published in English and French; those submitted in one language only are translated by the *Journal*.

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Illustrations should be submitted in triplicate as photographs (*glossy prints*) no larger than a standard page and must accompany the manuscript. Prints should not be mounted, stapled, or clipped. Symbols, letters, and numerals must be neat, and at least 1.5 mm high when the illustration is reduced to the appropriate size. Drawings should, when possible, be grouped to facilitate comparisons.

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Are the findings, interpretations, and conclusions adequately documented and relevant to the purpose of the study?

Are all the tables and figures needed, and organized to facilitate comparisons? Are there inconsistencies between tables or figures and the text, or within the text? Should some of the data be made available separately, in a manuscript report or at a data repository? If you use statistical analysis are the statistics subordinate to the research?

Would any of the text be clearer if condensed? Are summary statements given at the beginning of sections and paragraphs, and are details in sections and paragraphs relevant to their topics? Does the organization of the manuscript follow logically from the statement of purpose in the introduction?

Does the *title* encompass the content of the report?

Does the *abstract* give the essentials of the new knowledge?

Is the *introduction* largely limited to the scope, purpose, and rationale of the study? Is review of the literature limited to defining the problem?

Are details of *materials and methods* limited to what scientists need in understanding the design of the study and in judging adequacy of the data?

Are generalizations on the *results* adequate? Are findings distinguished from inferences from them?

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Nous désirons reçevoir des manuscrits s'insérant dans le vaste domaine de la gestion des pêches, des sciences de la mer et des milieux aquatiques au Canada.

Articles: Comptes rendus d'études d'une portée générale, constituant des contributions inédites à la science.

Notes: Se distinguent des articles par la portée et le degré d'achèvement plutôt que par la qualité des recherches. Elles peuvent traiter de problèmes particuliers et bien définis; de travaux qui sont en grande partie confirmatoires; de méthodologie ou de techniques de recherche; de progrès de la connaissance découlant d'études plus vastes; de développements dans des projets abandonnés; ou de découvertes préliminaires qui méritent d'être publiées avant la solution de problèmes à l'étude. Les notes peuvent être présentées d'une façon aussi souple que les articles, mais elles ne doivent pas porter d'en-têtes centrés ni occuper plus de quatre pages.

Critiques: Articles détaillés constituant une appréciation critique de vastes champs de recherches, particulièrement dans les domaines ayant connu de rapides progrès au cours des dernières années.

Perspectives: Essais de l'opinion ou de l'hypothèse sur les pêches, les sciences de la mer, les milieux aquatiques, ou sur des sujets connexes qui intéressent professionnels et profanes. Il est préférable de donner des références et d'écrire, si possible, dans un style simple.

Lettres: Opinions sur des sujets exposés dans le *Journal*. Longueur maximale préférable: 500 mots. Le directeur se réserve le droit de raccourcir les lettres et de faire d'autres modifications dans le style du *Journal*.

Dispositions générales

Le *Style Manual for Biological Journals* (3e éd., publié par l'American Institute of Biological Sciences, 3900 avenue Wisconsin N.O., Washington, D.C.) sert de guide quant à la forme de présentation. Le *Webster's Third New International Dictionary* et le *Grand Larousse Encyclopédique* font autorité pour l'orthographe des mots. Les titres de périodiques sont abrégés suivant les *Biological Abstracts*. Les références bibliographiques dans le texte doivent suivre le système nom de l'auteur-année. Pour les noms de poissons et leur orthographe, le *Journal* suit les recommandations contenues dans *A List of Common and Scientific Names of Fishes from the United States and Canada* (Troisième édition, 1970), Publication spéciale No. 6 de l'American Fisheries Society.

Il faut éviter les *articles en série*. Un *résumé* doit accompagner chaque texte et doit exposer brièvement (moins de 250 mots) le travail accompli, les points essentiels des connaissances acquises et les principales conclusions. Les résumés paraissent en anglais et en français, le *Journal* veillant à la traduction dans le cas des présentations unilingues.

Le directeur soumet d'ordinaire chaque texte à l'approbation de deux *arbitres* ou plus. Nous encourageons les collaborateurs à suggérer au moins quatre personnes dont les noms pourraient figurer sur la liste des arbitres.

Les *illustrations* doivent être sous forme de photos (*sur papier glacé*), ne pas dépasser les dimensions d'une page normale et accompagner le texte. Elles ne doivent pas être montées, coupées ni brochées. Les symboles, lettres ou chiffres doivent se détacher avec précision et avoir au moins 1,5 mm de hauter lorsque l'illustration est réduite à la grandeur voulue. Les dessins doivent, autant que possible, être groupés pour faciliter l'étude comparative.

L'auteur doit revoir les *épreuves* qu'on lui remet et en corriger seulement les erreurs typographiques. *Il doit éviter de changer le contenu du texte.*

Cinquante *tirés à part* sont fournis gratuitement. Les tirés à part peuvent être achetés au moment de la publication. Un bon de commande à cet effet accompagne les épreuves; il doit être retourné en même temps que celles-ci, non pas au bureau de la rédaction, mais au Printing Department, University of Toronto Press, 5201 Dufferin Street, Downsview, Ont. M3H 5T8, qui se chargera de la facturer. Les frais sont de $30.00 par page pour la publication des articles. Quand un auteur soumet un manuscrit, il doit spécifier que son institution accepte les frais.

Listes de contrôles pour manuscrits

Une attention particulière aux questions suivantes facilitera l'évaluation des manuscrits par les arbitres et les éditeurs.

Les découvertes, interprétations et conclusions sont-elles bien documentées et pertinentes au but de l'étude?

Les tableaux et figures sont-ils tous nécessaires et agencés pour faciliter les comparaisons? Y a-t-il contradiction entre les tableaux ou les figures et le texte, ou dans le texte même? Est-ce que certaines données devraient être présentées séparément, dans un rapport manuscrit ou dans un dépôt de données? Si vous faites une analyse statistique, la statistique cède-t-elle le pas à la biologie?

Le texte y gagnerait-il en clarté s'il était plus condensé, en tout ou en partie? Contient-il des exposés sommaires au début de chaque section ou paragraphe, et les détails de ces sections et paragraphs son-ils pertinents au sujet traité? La marche du manuscrit est-elle conforme à la logique énoncée dans l'introduction?

Le *titre* est-il concis, tout en étant représentatif du contenu du rapport?

Le *résumé* donne-t-il l'essentiel des connaissances nouvelles?

L'*introduction* se limite-t-elle à une esquisse de la portée, du but et des raisons de l'étude? La revue de la littérature se limite-t-elle à la définition du problème?

La section *matériel et méthode* contient-elle le minimum de détails qui permettront aux autres scientifiques de saisir les grandes lignes de l'étude et de juger de la valeur des données?

Les généralisations sur les *résultats* sont-elles adéquates? Permettent-elles de distinguer entre constatations et déductions?

La *discussion* est-elle limitée à l'interprétation et à l'évaluation des découvertes?

Journal of the Fisheries Research Board of Canada

Guide for Typists Preparing Copy

Read "Guide for Authors" in the current volume of the *Journal*. When in doubt about how to type or arrange details, follow *Journal* practice.

Type the manuscript on white bond paper, not flimsy, preferably size 21.5 × 28 cm (8.5 × 11 inches). If possible, use paper with the lines numbered in the margin. Leave all margins at least 2.5 cm wide.

Double-space all parts of the manuscript, including tables, captions for illustrations, footnotes, and the reference list. Underline only material that is to be printed in italics. Indent the first line of each paragraph in the text and of each footnote.

In titles and headings, capitalize only the first word and proper names and adjectives. For small capitals, use small letters.

Indicate all text footnotes by superscript arabic numerals. Number them consecutively throughout the manuscript, starting with those on the title page. Place each footnote immediately below the reference to it, separating it from the text by horizontal lines.

On the first page type only the title, the authors' names and affiliations, related footnotes, and the running head (see Appendix A). Type the abstract on a separate page (see Appendix B). Number all pages, beginning with the title page and including those for tables and captions for illustrations.

Have the author check the finished manuscript, and send the ribbon copy and two other clear copies to the Office of the Editor.

Tables: Examine the current volume of the *Journal* to see how tables are set up (see Appendix C).
Note especially the following concerning *numbered tables:*

Type each on a separate page, using paper without the lines numbered.

Number them with arabic numerals.

Use horizontal lines above and below the headings and below the columns, and seldom elsewhere. Never use vertical lines; leave extra spaces instead.

Indicate table footnotes by superscript small letters and type them below the table.

Place the tables after the list of references.

Where each table is first referred to, type in the margin "Table — near here."

Note that *text tables* are not numbered, are typed with the text, and seldom need horizontal lines (see Appendix C).

Illustrations: Send at least 3 *glossy prints* (no larger than 21.5 × 28 cm) of each illustration with the manuscript. Type the author's name and figure number on a strip of paper and fasten it to the back of the print. Do not write or type on the print itself. Also, type the captions in succession on a separate page, headed "Captions for illustrations." Put this page at the end of the manuscript.

Where each figure is first referred to, type in the margin "Fig. — near here."

Mathematical Expressions, Equations, and Formulas: Leave three spaces above and below lines that have much material in superscripts, and above and below equations and formulas. In the various expressions, place each component in its correct position (see Appendix D).

Show all symbols clearly. In the margin, spell out Greek letters the first time they occur, and distinguish between the small letter *l* and the numeral *one*, and between the capital letter *O* and the numeral *zero*. Make other explanatory notes similarly.

References: Check the text to see that all references in the list are referred to. Type the reference list, double-spaced, in the style used in the *Journal* (see Appendix E). Names of journals are abbreviated as in the *Biological Abstracts* list; if an abbreviation is in doubt, type the name in full.

Spellings: About 100 words common in fisheries journals are listed in Appendix F.

Appendices: Appendices A to F are available on request from the Office of the Editor.

Journal de l'office des recherches sur les pêcheries du Canada

Guide pour les secrétaires d'auteurs

Lisez le "Guide des Auteurs" reproduit dans l'édition courante du *Journal*. Si vous avez des doutes sur la façon de dactylographier le texte ou d'en agencer les détails, suivez la pratique du *Journal*.

Dactylographiez le manuscrit sur papier blanc de bonne qualité, et non sur papier pelure, mesurant de préférence 21,5 × 28 cm (8,5 × 11 pouces), laissant toujours une marge d'au moins 2,5 cm. Si possible, employez un papier avec lignes numérotées en marge.

Tout le manuscrit, y compris tableaux, légendes de figures, renvois et références bibliographiques, devra être dactylographié à double interligne. Ne soulignez que les mots qui devront être imprimés en italique. Mettez en retrait la première ligne de chaque paragraphe du texte et de chaque renvoi.

Dans les titres et les en-têtes, n'employez la majuscule que pour le premier mot et les noms propres. Pour les petites majuscules, employez les miniscules du dactylographe.

Indiquez tous les renvois du texte par des chiffres arabes suscrits. Numérotez les renvois consécutivement par tout le texte, à commencer par ceux de la page titre. Placez chaque renvoi directement sous sa référence, le séparant du texte par des lignes horizontales.

La première page ne doit contenir que le titre de la publication, ne nom et l'affiliation des auteurs, les renvois appropriés et le titre courant (voir Appendice A). Dactylographiez le résumé sur une page séparée (voir Appendice B). Numérotez chaque page, à commencer par la page titre, et y compris celles qui contiennent les tableaux et la légende des figures.

Voyez à ce que l'auteur vérifie le manuscrit final, et soumettez la première copie et ainsi que deux copies lisibles au bureau du Directeur de la publication.

Tableaux. Consultez une copie du *Journal* pour la composition des tableaux (voir Appendice C).

Portez une attention particulière à ce qui suit au sujet des *tableaux numérotés*.

Dactylographiez chaque tableau sur feuille séparée, vous servant de papier sans lignes numérotées.

Numérotez les tableaux en chiffres arabes.

Tracez des lignes horizontales au-dessus et au-dessous des en-têtes et au-dessous des colonnes, rarement ailleurs; ne tracez jamais de lignes verticales; laissez plutôt des espaces supplémentaires.

Indiquez les renvois dans les tableaux par les minuscules suscrites et placez les renvois au bas du tableau.

Placez les tableaux à la suite des références bibliographiques.

A l'endroit où le tableau est mentionné pour la première fois, indiquez dans la marge "Tableau — près d'ici."

Remarquez que les *tableaux dans le texte* ne sont pas numérotés, sont dactylographiés avec le texte et ne requièrent que rarement des lignes horizontales (voir Appendice C).

Figures: Envoyez avec le manuscrit trois photos *sur papier glacé* (21,5 × 28 cm ou moins) pour chaque illustration. Dactylographiez le nom de l'auteur et le numéro de la figure sur une lisière de papier que vous collerez au dos. N'écrivez pas à la main ou à la machine sur la photographie même. En plus, dactylographiez les légendes, dans l'ordre, sur feuille séparée, intitulée "Légendes des figures." Intercalez cette feuille à la suite du texte.

A l'endroit où chaque figure est mentionnée pour la première fois, inscrivez en marge "Fig. — près d'ici."

Equations, formules et expressions mathématiques: Laissez trois espaces au-dessus et au-dessous des lignes renfermant des chiffres ou des lettres suscrits et souscrits, ou encore au-dessus et au-dessous d'équations et de formules. Placez chaque composante des différentes expressions dans la position qui lui est propre (voir Appendice D).

Indiquez clairement tous les symboles. Epelez en marge les lettres grecques, la première fois qu'elles apparaissent. Faites une distinction entre la lettre *l* et le chiffre *un*, et entre la majuscule *O* et le chiffre *zéro*. Insérez de la même façon toute autre note explicative.

Références: Vérifiez le texte afin de vous assurer que toutes les références apparaissant dans la liste bibliographique sont bien mentionnées dans le texte. Dactylographiez à double interligne dans le style en usage dans le *Journal* (voir Appendice E). Les noms de revues sont abrégés suivants les *Biological Abstracts*; en cas de doute, écrivez le nom au long.

Orthographe: Une liste d'environ 100 mots communément employés dans les périodiques sur les pêches est donnée en Appendice F.

Appendices: On peut se procurer une copie des Appendices A à F sur demande au bureau du Directeur de la publication.

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W. H. Lear and O. Christensen 1223–1228

Incidental catch of cetaceans with salmon gillnets
S. Ohsumi 1229–1235

Marking of small cetaceans using "Discovery" type whale marks
S. G. Brown 1237–1240

Coming next month/À paraître le mois prochain 1241–1242

Guide for authors and typists/Guide des auteurs et Guide pour les secrétaires d'auteurs *i–v*

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